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Envisioning Yantian Urban Greenway: A Part of Pearl River Delta Greenway System in China

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ENVISIONING YANTIAN URBAN GREENWAY
A Part of Pearl River Delta Greenway System in China

A Master's Project Presented

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ABSTRACT

This master project proposes an urban greenway for Yantian district in Shenzhen, China. Various challenges in the selected area are analyzed including urban green space fragmentation, water pollution, high building density, lack of open space, singular land use and loss of cultural identity. A greenway solution is proposed based on field visit/study, literature review, background data study and case studies. Greenway theories and precedence study provide guidance on the selection of strategies to deal with those challenges in the urban area. Specific sustainable urban development concepts such as stormwater management, material reuse and mixed land use are adopted.

The greenway design proposal includes a larger scale urban area conceptual plan and a focused area schematic plan. Multiple functions have been proposed to deal with the complex urban challenges. The broader scale plan creates a green network of land that heals the land fragmentation and water pollution of Yantian River. The finer scale plan creates a green connection between two forest parks with other functions like public open space, stormwater treatment, environmental education and water remediation. This multi-level and multi-functional urban greenway explores the possibility of a more sustainable urban environment in the future for the Yantian district.

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CHAPTER 1 - Project Introduction & Literature Review

1.1. Project Introduction

This project will propose an urban greenway in Yantian district of Shenzhen in China as an important part of the overall Pearl River Delta (PRD) Greenway System. The designed urban greenway will go through an urban district and along the Yantian River to provide connections between the fragmented green spaces, add recreational public areas, support environmental education and perform multiple other ecological functions including stormwater management, habitat creation, and climate mitigation. This multi-functional urban greenway will be integrated into the broader scale Shenzhen greenway system and act as a model for ecological urban greenway planning in the Guangdong Province.

1.2. Literature Review

1.2.1. The definition of Greenway

Greenways have been defined as, “linear open space established along either a natural corridor, such as a riverfront, stream valley, or ridgeline, or overland along a railroad right-of-way converted to recreational use, a canal, a scenic road, or other route” (Little, 1990; Flink and Searns, 1993). Furthermore, comprehensive greenway networks include ecological, recreational and cultural heritage aspects (Fabos, 1995).

Jongman defines greenways as “a passage for people and their access to the countryside, adding the function of linkage between the urban and rural American landscape”. He also emphasizes that comprehensive greenway design includes ecological, recreational and cultural aspects.” (Jongman, 2004).

Other definition includes: “Greenways are corridors of land and water that provide significant social and ecological benefits”(Hellmund and Smith 2006) and “Greenways are networks of land containing linear elements that are planned, designed and managed for multiple purposes including ecological, recreational, cultural, aesthetic, or other purposes compatible with the concept of sustainable land use.”(Ahern, 1995, 134)

Although those definitions are different from each other, there is general agreement that greenways are networks of land, and it has two key characteristics: connectivity and multi-functionality. Also worth mentioning is that greenway terminology is inconsistent around the world. In recent literature there are numerous names given to “Greenways” including: ecological infrastructure, ecological framework, ecological network, extensive open space systems, multiple use modules, habitat networks, wildlife corridors, and landscape restoration framework. (Ahern, 2002).

Greenway will provide linkage to the fragmented resource in this project and perform its multi-functionality in the selected urban site as a linear sustainable landscape structure.

1.2.2. Greenway Planning and Landscape Ecology

With the growth of population and urbanization in the developing world, land use has intensified rapidly; there is a decrease in landscape heterogeneity and an increase in fragmentation of the landscape. Both have negative biotic and abiotic consequences on the landscape. An international consensus to these global land use trends looks for a more "sustainable landscape" condition, in which the needs of the present are met without compromising the ability of future needs to be met (WCED 1987, IUCN 1980).

In responding to the call of "sustainability", landscape ecology has been brought into the front stage for planning and design strategies. Landscape ecology employs the "patch:corridor:matrix" spatial model to describe and analyze landscape configuration. This analysis often identifies the need for corridors and stepping stones to connect isolated patches – within and across the landscape matrix. In this context, corridors that link patches have great potential importance to mitigate the effects of fragmentation, and be planned as local-scale greenways, or parts of larger regional-scale greenway systems (Fig 1 & 2).

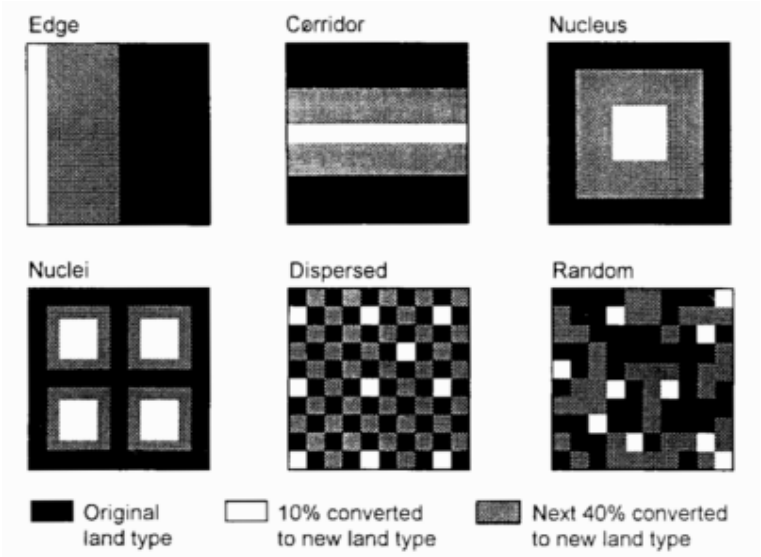


Fig 1. Models of mosaic sequences in the context of landscape change. The Edge model is considered to have the best connectivity and large patch.(Forman, 1995, P424)

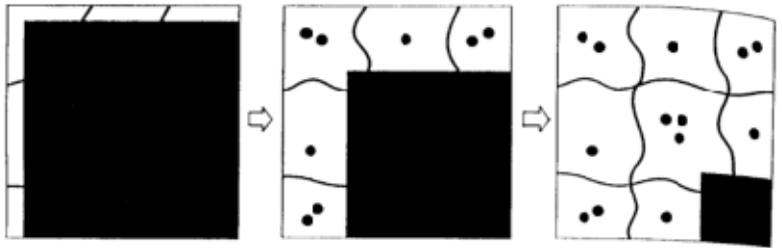


Fig 2. "Jaws" model of land transformation in a binary landscape. . This model is considered to be an optimum way to preserve large patches and corridor connections while the landscape is changed – typically as with urbanization .(Forman, 1995, P430)

However, it is not possible or appropriate to implement "patch and corridor" plans solely intended for the protection of biotic resources because of competing land use demands and needs. A multi-purpose conservation network is arguably more appropriate in most human-dominated landscapes. Networks, by definition are systems that support a range of functions by way of connectivity. Connectivity refers to the degree to which a landscape facilitates or impedes the flow of energy, materials, nutrients, species, and people across a landscape (Forman 1986). Greenways are networks that provide multiple functions including: recreation, wildlife habitat and movement, water resource management and cultural resource connections (Ahern 1995). Because of the multifunctional nature and emphasis on connectivity, greenways are ecologically "friendly" to most landscapes.

Therefore, greenways, which may serve as a multifunctional network, could link the isolated patches and reduce fragmentation. In the selected site of this project, where the fast urbanization is breaking the healthy landscape and creating fragmentation, greenways can be used as an ideal strategy to deal with the challenges.

1.2.3. Greenway and Sustainable Urban Design

1.2.3.1. Urban Greenway

Greenways have played a significant role in urban development. The concept of urban greenways dates back to the 19th century. Searns separated the development of urban greenway concept into three generations: The first two generations of greenways were primarily amenity oriented; they were developed to address aesthetic and recreational needs of city dwellers. Ancestral greenways

(pre-1700s–1960s) grew out of the axis concept to link urban spaces and evolved into corridors that introduced nature into the city. As an adaptive response, the second generation of greenways (1960–1985) reacted to the ills of industrialization through motor-free recreational corridors. However, it wasn't until the newer third-generation greenways (1985 and beyond) that a broad spectrum of objectives were addressed to include wildlife and habitat preservation, reduction of urban flood damage, enhancement of water quality, preservation of cultural resources, provision of recreational corridors, urban beautification, and educating the public. Third generation greenways thus constitute a potential tool to address a range of issues (Searns, 1995).

1.2.3.2. Sustainable Urban Design

It is estimated that more than 50% of the world's population now lives in cities and urban areas (UN Report, 2007) . These large urban communities provide both challenges and opportunities for environmentally-conscious developers. In order to make cities more sustainable, building design and practice, as well as perception and lifestyle must adopt sustainable thinking. Sustainability is commonly understood through three categories: ecological, cultural and economic sustainability. Economic sustainability is achieved by effective urban systems with low impact on the environment by using technology with community-based development strategies. Cultural sustainability deals with preserving and sustaining local cultural identity and tradition under the circumstance of fast globalization. Ecological sustainability will work by taking nature as a system, planning and designing in accordance with its process (Ian McHarg, 1987).

1.2.3.3. Urban Water Management

Urban water management is a major concern of sustainable urban development. Urban water generally includes rainfall, groundwater, river or stream water, industrial water, irrigation water and drinking water (Girling, 2005). The management of urban water deals with water supply, purification, flood prevention, drainage and wastewater treatment. Carefully designed urban drainage systems contribute to runoff reduction and flood prevention. In urban development, the most obviously affected urban water is stormwater (Girling, 2005).

Green roofs, also know as "living roof", is a strategy to facilitate sustainable stormwater management (Fig. 3). It's partially or completely covered with vegetation and a growing medium, planted over a waterproofing membrane. Vegetation on the green roof can reduce urban run off and return water to the atmosphere through evaporation. Extra water can be drained into a cistern for other use.

Fig 3. Green Roof. (Image resource: http://www.courierpress.com/news/2010/nov/16/gardener-green-roofs-and-rooftop-gardens/)

Rain gardens are another strategy to capture and conserve urban sotrmwater. A rain garden is usually a shallow depression that is planted with native wetland or wet prairie wildflowers and grasses. It is strategically located to capture runoff from impervious surfaces such as roofs, driveways, parking lots, and roads(Fig 4). Rain gardens catch the rain shower before it drains into the storm drainage system, and settle down the sediments and pollutant it brings. The plant roots and soil will absorb and purify the pollutants afterwards.

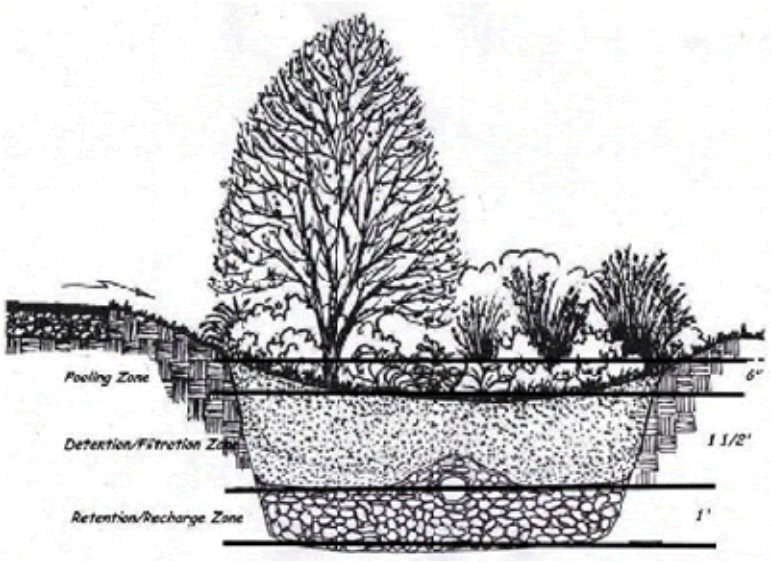


Fig 4. Cross section view of typical rain garden. (Image resource: http://www.dmgov.org/Departments/Parks/Pages/RainGardens.aspxx)

Wastewater treatment is another important issue in urban water management. Conventional wastewater treatment is a technological, chemical-based process using chemical agents to kill bacteria without recycling water or nutrients. An ecological way of treating wastewater is to imitate natural wetland functions, use natural process and system to gradually detoxify and purify wastewater.

Denitrification is a major function of natural wetlands which removes the Nitrates in waste water (Fig 5), while constructed wetlands (Fig 6) could emulate the process. Kadlec and Alvord, (1989) found that in a system treating 400,000 cubic meters of wastewater/year:

1) 96% of total Phosphorous (P) was removed;

2) 97% total ammonium was removed

3) Denitrification removed Nitrates 100%;

4) Sediments accumulated, and plant species changed.

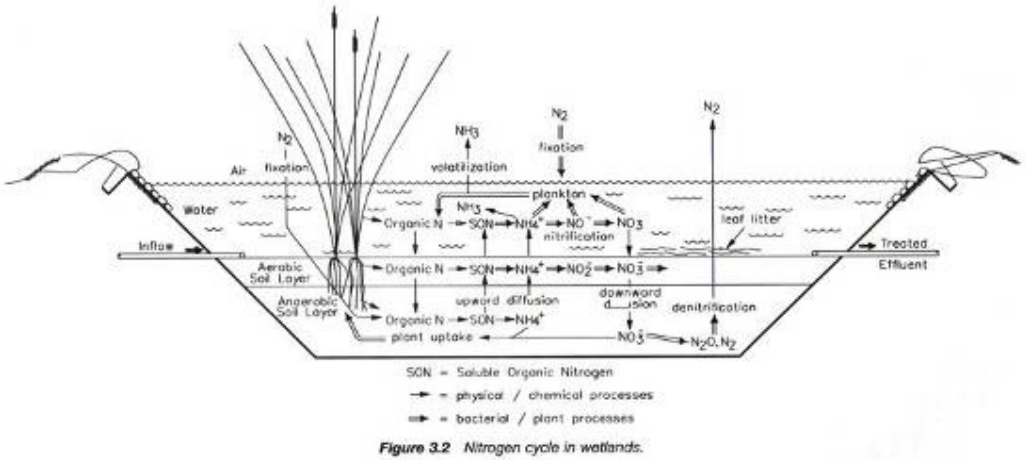


Figure 3.2 Nitrogen cycle in wetlands.

Fig 5. Nitrification and Denitrification Process in a constructed Wetland(Image resource: http://www.selba.org/gedseng/ecological/water/Denitrification.html).

Fig 6. Constructed Wetland in Shanghai Houtan Park(Image resource: http://www.asla.org/2010awards/006.html).

Besides improving water quality, wetlands are well-recognized as "hotspots" of biodiversity and providers of numerous hydrological, ecological and cultural functions such as habitat for wildlife and plants, flood protection and recreational, educational opportunities" (Ahern, 2006).

1.2.3.4. Conclusion

The greenway's inheritance of multi-functionality makes it an appropriate approach for sustainable urban development. The connectivity of green space, the ecological and recreational functions and the requirement for non-vehicle transportation all contribute to a more sustained, healthy and functional urban space. Under current condition of rapid urbanization, urban greenway has a great potential and invaluable opportunity for landscape architects.

1.2.4. History and Current State of Greenway.

1.2.4.1. The Origin of Greenway in America and Its History

The history of Greenway planning in America could be generally organized in five phases (Fabos, 2004):

Phases	Time	Important Landscape Planner	Contributions
1	1867 to 1900	Frederick Law Olmsted; Charles Eliot	Boston Park System; Metropolitan Park System of Boston
2	1900 to 1945	Olmsted Brothers; Henry Wright; Charles Eliot II	40-Mile Loop in Oregon, Portland; First open space plan for the state of Massachusetts
3	1960s and 1970s	Phil Lewis; Ian McHarg; Ervin Zube; Julius Gy. Fabos	Wisconsin Heritage Trail; <<Design with Nature>>; METLAND team's research
4	1980s and 1990s	Charles Little	<<Greenways for America>>
5	1990 to current	D.S. Smith and P. Hellmund; Flink and Searns; Fábos and Ahern	<<Ecology of Greenways>>; <<Greenways: a Guide to Planning, Design and Development>>; <<The Beginning of an International Movement Design and Development>>

The evolution of greenway planning started with Frederick Law Olmsted's Boston's Emerald Necklace, also known as the Boston Park System. The Necklace comprises half of Boston's park acreage, parkland in the Town of Brookline, and parkways and park edges under the jurisdiction of the Commonwealth of Massachusetts. More than 300,000 people live within its watershed area. The Emerald Necklace is the only remaining intact linear park designed by Frederick Law Olmsted(Emerald Necklace Conservancy). This park system not only offers an opportunity for recreation in a wooded environment, but are also ecologically important urban wilds (Fig 7) that provide nesting places for migratory birds and improve the air quality of the city. From Boston Common to Franklin Park it is approximately seven miles by foot or bicycle through the parks (Fig 8). The Emerald Necklace includes the following parks (City of Boston.gov):Boston Common; Public Garden; Commonwealth Avenue Mall; Back Bay Fens; The Riverway; Olmsted Park; Jamaica Pond; Arnold Arboretum; Franklin Park.

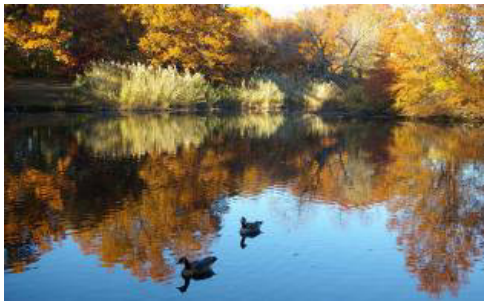


Fig 7. Wild life habitat in Boston Emerald Necklace (Image resource: http://www.emeraldnecklace.org)

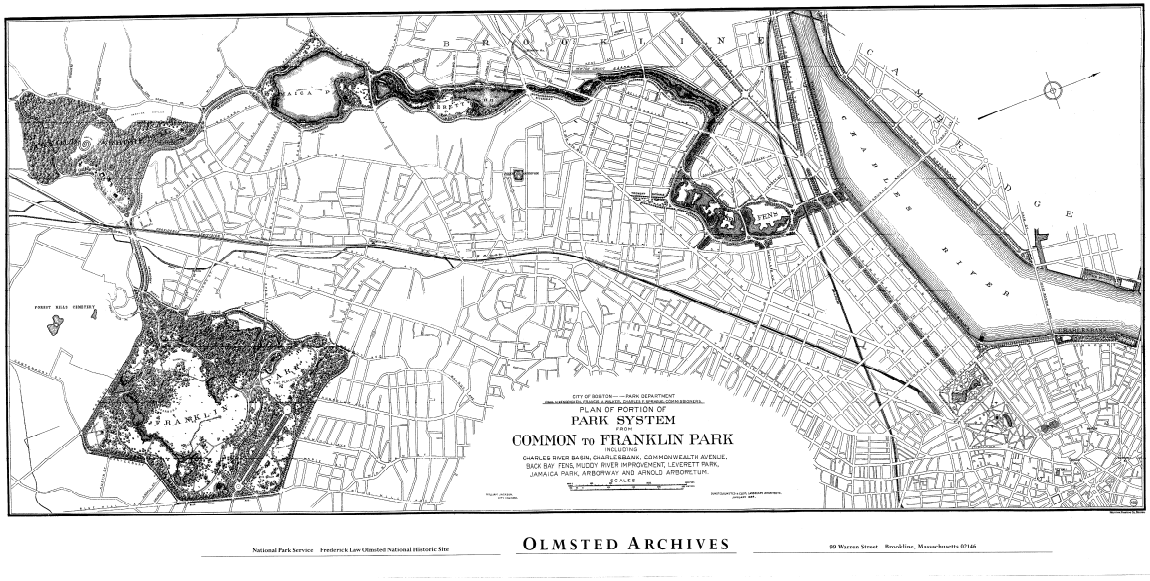


Fig 8. Master Plan of Boston Emerald Necklace (Image resource: http://www.google.com/imgres?imgurl=http://upload.wikimedia.org/wikipedia/commons/4/4b/Olmsted_historic_map_Boston.png&imgrefurl=http://wn.com/Emerald_Necklace&usg)

Based on Olmsted's proposal, Charles Eliot, Olmsted's pupil extended the concept to the entire Boston Metropolitan Region of around 600 km2 (Fabos, 2004). Charles Eliot's visionary plan linked together five large parks on the outskirts of the Boston metropolis (Fig 9).

The linkages were accomplished through five shorter coastal river corridors, such as the Charles River Greenway Corridor to the ocean and the Boston Back Bay area (Fábos, 1968).

Fig 9. Metropolitan Park System of Boston (Image resource: wikipedia)

The evolution was continued during the early 20th century. This time, Henry Wright, Olmsted's two sons, known as the Olmsted brothers and Eliot's nephew Charles Eliot II expanded the work of Olmsted and Eliot (Fabos, 2004). The Olmsted brothers' most influential work

is a 40-mile long park system in Portland, simply called the “40-Mile Loop” (Little, 1990)(Fig10). Charles Little regarded it as “one of the most creative and resourceful greenway projects in the country.” Another important figure at this time is Henry Wright, one of the most important American planners in the 20th Century, he is renowned for his map overlaying methods and most of his works are in the state of New York (Krueckeberg,1983). He also played a significant role in community planning, especially recognized for his input in Radburn, NJ. A significant landscape plan of this period was the first open space plan for the state of Massachusetts (Fig.11), which was a broad green network of over 250km proposed by Charles Eliot II linking important landscapes across the state (Fabos, 1985).

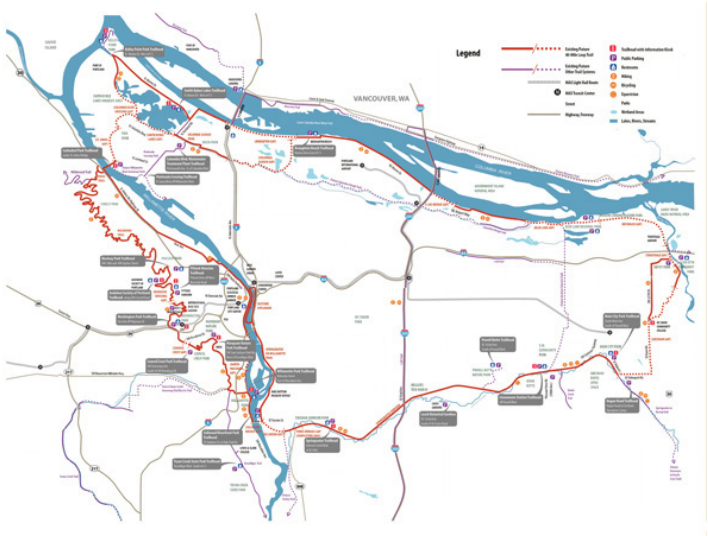


Fig 10. 40-Mile Loop in Portland, Oregon (Image resource: http://www.walkaboutmag.com/43footpaths.html)

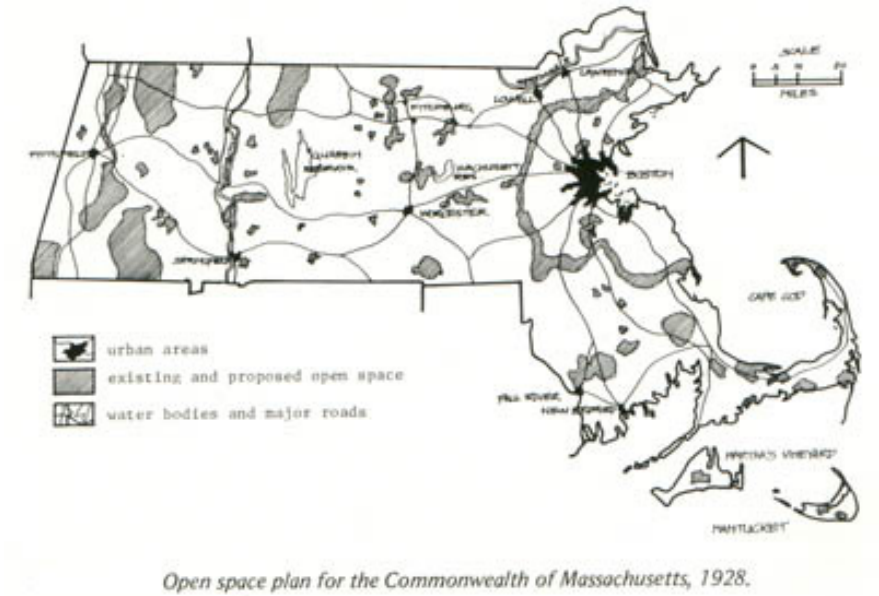


Fig 11. The first open space plan for the state of Massachusetts Image resource:http://www.umass.edu/greenway/Greenways/2GR-his.html)

The next phase of greenway evolution was by Phil Lewis, Ian McHarg and others during the post-World War II decades, also known as the environmental decades. Lewis' contribution to the field includes an important plan called Wisconsin Heritage Trail Proposal in which he found that important environmental, recreational and cultural resources generally concentrate along linear spaces which he called

"environmental corridors"(Lewis,1964)(Fig 12). This discovery is a strong proof of the co-occurrence of greenway resources that states the important ecological, cultural-historic and recreational resources are spatially concentrated in corridors (Ahern 1995). Another significant figure at this time is Ian McHarg, one of the most influential landscape architects. His book "Design with Nature" systematically describes the ecological landscape planning method. In a chapter about protecting the "valley floor" from development, around half of the area is proposed to be part of a greenway–greenspace network (Fig.13). The result of the McHarg's plan for the valley floor is similar to Lewis' "environmental corridors" proposal. Also during this period, William H. White, a prominent environmental writer, invented and used the term "Greenways" in his 1959 monograph entitled, *"Securing Open Space for Urban America."*

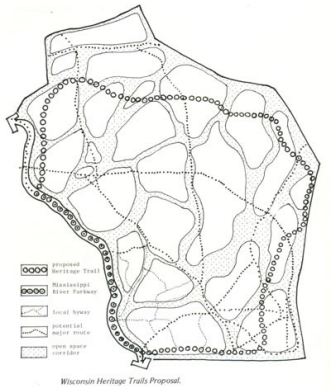


Fig 12. Wisconsin Heritage Trail Proposal. (Image resource: http://www.umass.edu/greenway/Greenways/2GR-his.html)

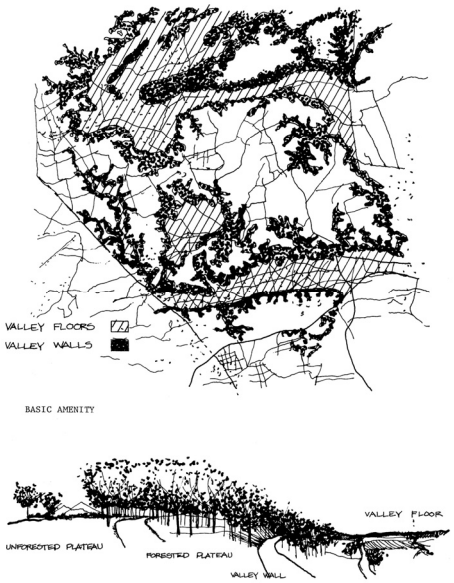


Fig 13. Plan for the Valleys, "Design with Nature", Ian McHarg (Image resource: Ian McHarg,1987)

In the 80s and 90s, the METLAND research team at the University of Massachusetts lead by Julius Fabos worked actively in promoting landscape planning. Different from McHarg's landscape approach, the METLAND team used parametric approach "which allows the use of infinite number of variables and can compare between and afford greater consistency and its suited to (assessment with) computers"

(Fábos, 1979). The team's famous masterpiece – New England Greenway Vision Plan will be described in detail as a case study in this paper.

1.2.4.2. The Origin of Greenway in China and Its History

Kongjian Yu states that although the concept of Greenway was an adaptation from the Western World, the Chinese have a history of more than 2000 years of Greenway planning and implementation. Chinese Greenways have been called various names and were planned for various reasons. The earliest Greenway planning could be traced back to the Zhou dynasty when the "Zhou Dao" avenue was built with consideration of using trees to define the road. There are also Greenways planned and built in the Qin dynasty, Han dynasty, Tang dynasty(Fig 14) and Ming dynasty (He, 2010).

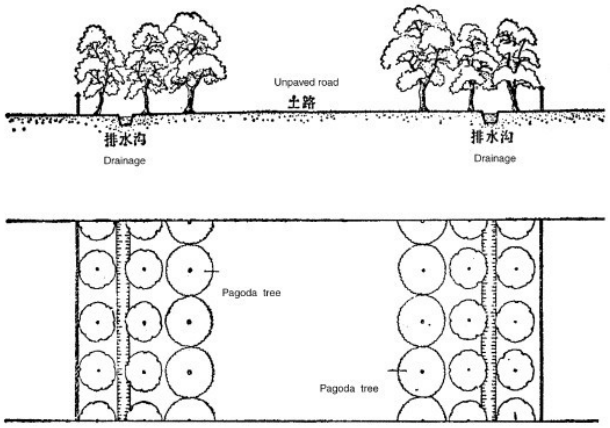


Fig 14. Green Road built in Tang Dynasty. (Image resource: Kongjian Yu, 2004, The evolution of Greenways in China, Landscape Urban Planning)

Greenways built in China before the 20th century considered production and protection functions as the priority. Other human uses, especially recreational uses and historical heritage protection, were not well considered. The Grand Canal (also known as Beijing – Hangzhou Grand Canal) built 2,500 years ago is the longest artificial canal of the world (Fig 15). The goal of this project is mainly about controlling the flood of Yellow river. The trees along both sides of the canal are a strong proof of its greenway character.

Fig 15. The Grand Canal in China. (Image resource: Wikipedia)

The top-down system of the Chinese feudal society had brought challenges to its land. The continuous unwise clearing of forests for rulers' grand palaces had worsened the thousands of years' natural disasters that have shaped the land and its people. During the contemporary age, the "iron and steel industry campaign"(Fig 16) in 1950s and "people's commune movement" in 1960s result in a significant cutting down of forests (Forestry Department, 1999). These natural disasters and poor decisions became triggers for the development of greenways in China in history as well as today. Thus, the evolution and formation of greenways in China have unique character which is shaped by the geographical and environmental situations in China, plus the social and political processes.

Fig 16. The iron and steel industry campaign in 1957. (Image resource: http://forum.book.sina.com.cn/thread-2787918-1-1.html)

In 1997, responding to the official call of "rebuilding beautiful mountains and rivers", a nationwide campaign was launched to build greenways along roads, railways, rivers and streams. The official announcement stated that, "the greening of road, railway, river and stream networks is critical in promoting the process of making the landscape beautiful". In 2000, the State Council delivered "a further call for the construction of green corridors at the national scale" to all provinces and departments of the country. They even proposed qualitative and quantitative principles for Greenway plantings.

Similar situations can be found in this project, the width of different functions of the Pearl River District (PRD) Greenway has been proposed. The top-down strategy is also the managing method of the PRD Greenway system. The 1,690 kilometer-long greenway, has been ordered to be completed with an incredibly rapid speed in 3 years from 2010 to 2012 which could bring many challenges and disadvantages.

1.2.5. Greenway Planning Process

Flink and Searns warn that “the greenway process can be long, taxing and at times frustrating.” because of its multiple scope, various stakeholders, the complexity of the planning and design process and some other outside factors such as economic crisis (Flink and Searns, 1993).

Jack Ahern proposed a Greenway planning process called the “Framework Method for Landscape Ecological Planning, a continuous participatory and interdisciplinary process”. (Fig 17) The first step is to develop landscape planning goals and assessments for abiotic, biotic and cultural resources within a study area. These assessments should then be analyzed to determine the “spatial compatibility and conflicts” (Ahern 1995). The second step is to develop planning strategies based on the resources of the region. Planning strategies consists of offensive, defensive, protective and opportunistic approach. Ahern emphasized that all strategies are “proactive and based on a goal-oriented plan”(Ahern, 1995).

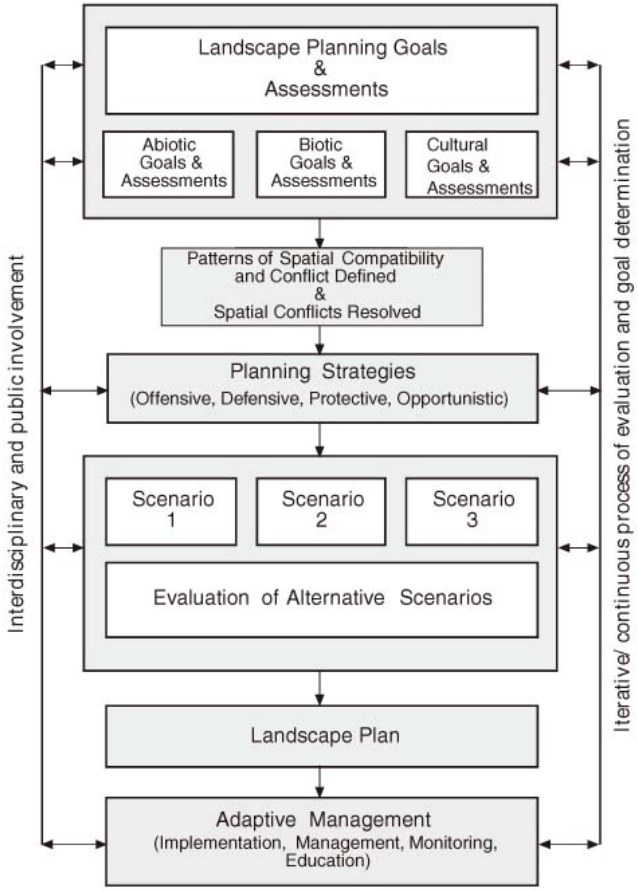


Fig17. The framework method for landscape ecological planning: an iterative, continuous, participatory and interdisciplinary process(Ahern, 2002)

The protective approach is used to support and maintain an existing healthy situation that supports sustainable patterns and processes. This approach protects a greenway landscape pattern from changes while allowing appropriate types and locations of changes around it. The defensive strategy is used in a landscape that is already stressed or fragmented and has many areas that are shrinking and isolated. This approach is to stop or slow down the fragmentation and isolation of patches, nodes and corridors of resources. The offensive strategy is usually based on a goal, a vision or a possible landscape configuration, it aims at bringing nature back to overused, damaged or "brownfield" landscapes. The opportunistic approach is used when there are special targets for protection that are often in corridors. The "rails-to-trails" movement in the US is a good example of this kind. This project will mainly use the offensive strategy to reconstruct nature in the selected urban area.

Flink and Searns describe three steps to develop a greenway plan: inventory and analysis, preparation of concept plan and preparation of a final master plan. The inventory and analysis look at the cultural and natural resources of the region. The concept plan is used to develop goals and objectives to guide the project. The master plan is about identifying specific project elements such as lands identified for acquisition, facility development plans and funding. Also, each of these stages can be broken down into more detailed steps.

Hellmund and Smith proposed five stages for greenway planning:

(1) Identifying Potential Issues, Stakeholders, and Preliminary Goals

(2) Defining a Broad Region to Study

(3) Selecting Nodes and Detailed "Swath"

(4) Selecting Alternative Alignments and Setting Widths

(5) Implementing and Managing

Fabos and the METLAND group proposed a five steps procedure for the New England Greenway Vision Plan which will be mentioned in the case study section.

CHAPTER 2 – Methodology

2.1. Goals and Objectives

1. To develop a greenway planning and design method for China – building on, and adapting from, existing methods from the international greenways literature.

2. To demonstrate the importance and urgency of greenway planning – in support of a vision for sustainable landscape planning in contemporary China.

3. To apply the greenway planning and design method to Yantian urban greenway in Shenzhen, China .

2.2. Research Methods

The research methods are conducted through literature review, background data search, field trip, case studies, and other mapping methods.

2.3. Organization of the Proposal

This proposal is divided into five chapters. Each chapter has several sections that describe the chapter in detail. Those sections between major chapters are of same importance to each other. The first chapter gives a brief introduction and literature review to the study. The second one describes the methods to develop this proposal. The third one is a summary of case studies. The following two chapters are about the project background, site analysis and design development.

CHAPTER 3 - Case Studies

3.1. Greenway Vision Plan for New England

Location: New England Region

Size: 46074973 acres = 18645880 ha

Landscape Architect: METLAND (metropolitan landscapes) team led by Professor Julius Gy. Fábos.

Time: 1999

The New England Greenway Vision Plan is selected as one of the precedence studies because this plan is similar to the PRD Greenway as a multi-level and multi-functional greenway plan. The New England Greenway Vision Plan was proposed to build on the history of greenway work by landscape architects such as Emerald Necklace by Frederick Law Olmsted; Charles Eliot's first plan of the Boston Metropolitan area and Charles Eliot II, nephew of Charles Eliot, who expanded his uncles' metropolitan wide plan into the first statewide open space plan. The plan's purpose was to expand the state plans into a New England wide, multi-state greenway vision plan.

The Greenway plan for New England takes its importance for two reasons. First, New England landscape is formed by mountain ranges and hills and rivers from north to south. The state boundaries that are superimposed on the New England landscapes do not respond to this natural landscape – for example, the Appalachian mountains extend through 5 New England States. Second, the coordination of planning among the six states is minimal, especially along the major river corridors. This type of political fragmentation limits the development of a logical comprehensive plan that respects the landscape resources (Fabos, 2004).

The study found that New England already has 18% of its area in existing protected greenspaces and greenways including over three million hectares. The Greenway connections within and between the greenspaces are over 30,000 km in length. Equally impressive was the finding that New England planners working for states, regions or non-governmental organizations were trying to increase the greenspaces by adding an additional 8% of the total area protected and over 6000 km of Greenway connections. This vision plan aims to increase the greenspaces in New England by another 19% and to add an additional 20,000 km of new Greenway connections. If these plans were implemented in addition to the current plans proposed within the region, 45% or close to half of New England would become protected or partially protected greenspaces. The region would have over 57,000 km of greenway connections for wildlife, recreation and historic and cultural sites mostly along the river networks (Fabos, 2004).

As proposed by Fabos and METLAND, the method of the New England Greenway planning includes a simple five step procedure designed to integrate existing greenways, current proposals by all agencies, non-profit groups and the proposals by planners to make greenways into a more complete and comprehensive—more specifically, the five steps are shown as the following diagram (Fig 18):

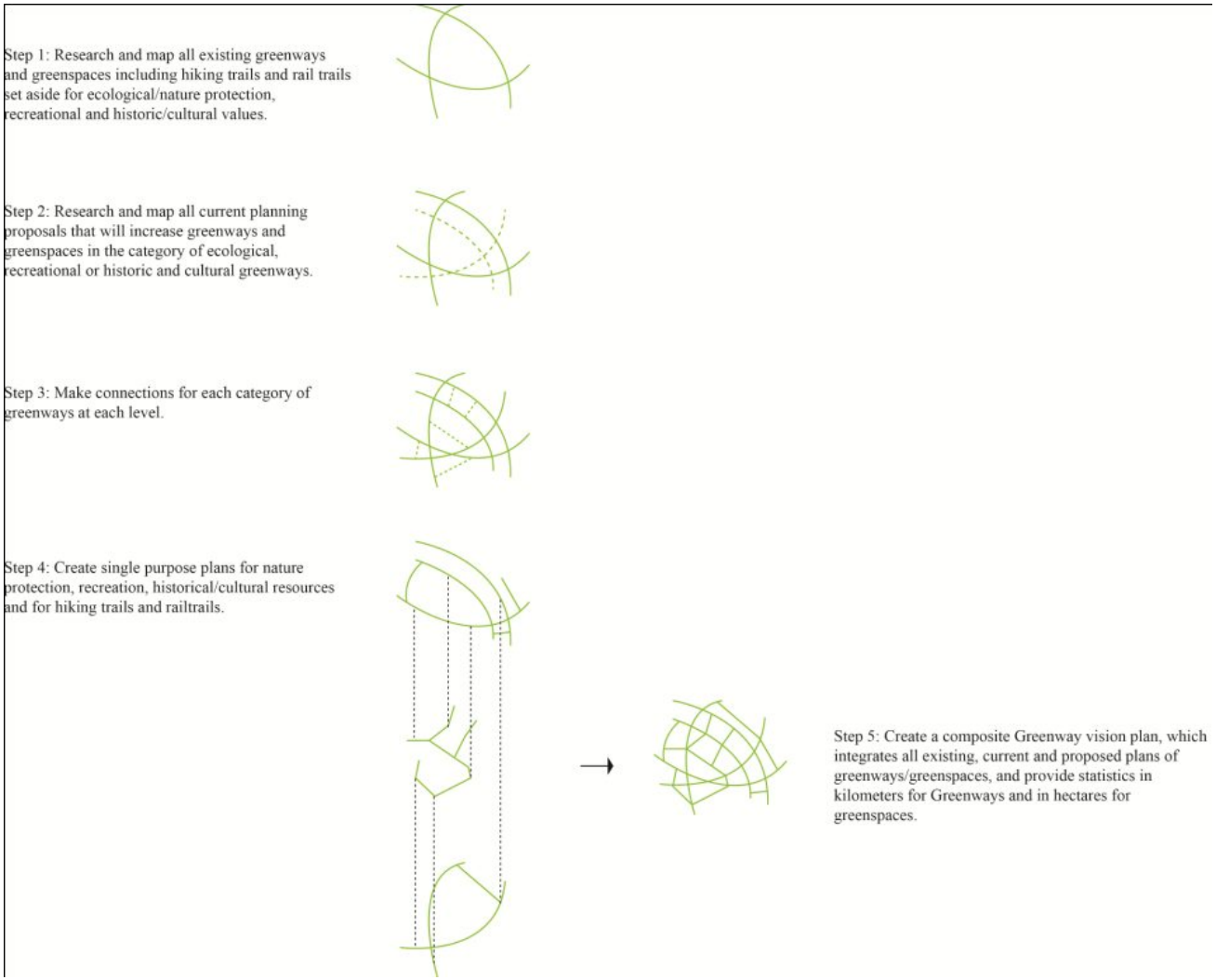


Fig18. The five steps for New England Greenway Vision Plan (Image resource: Xiao Zhou)..

As mentioned above, this vision plan is a multi-level plan. The levels it includes are shown here (Fig 19):

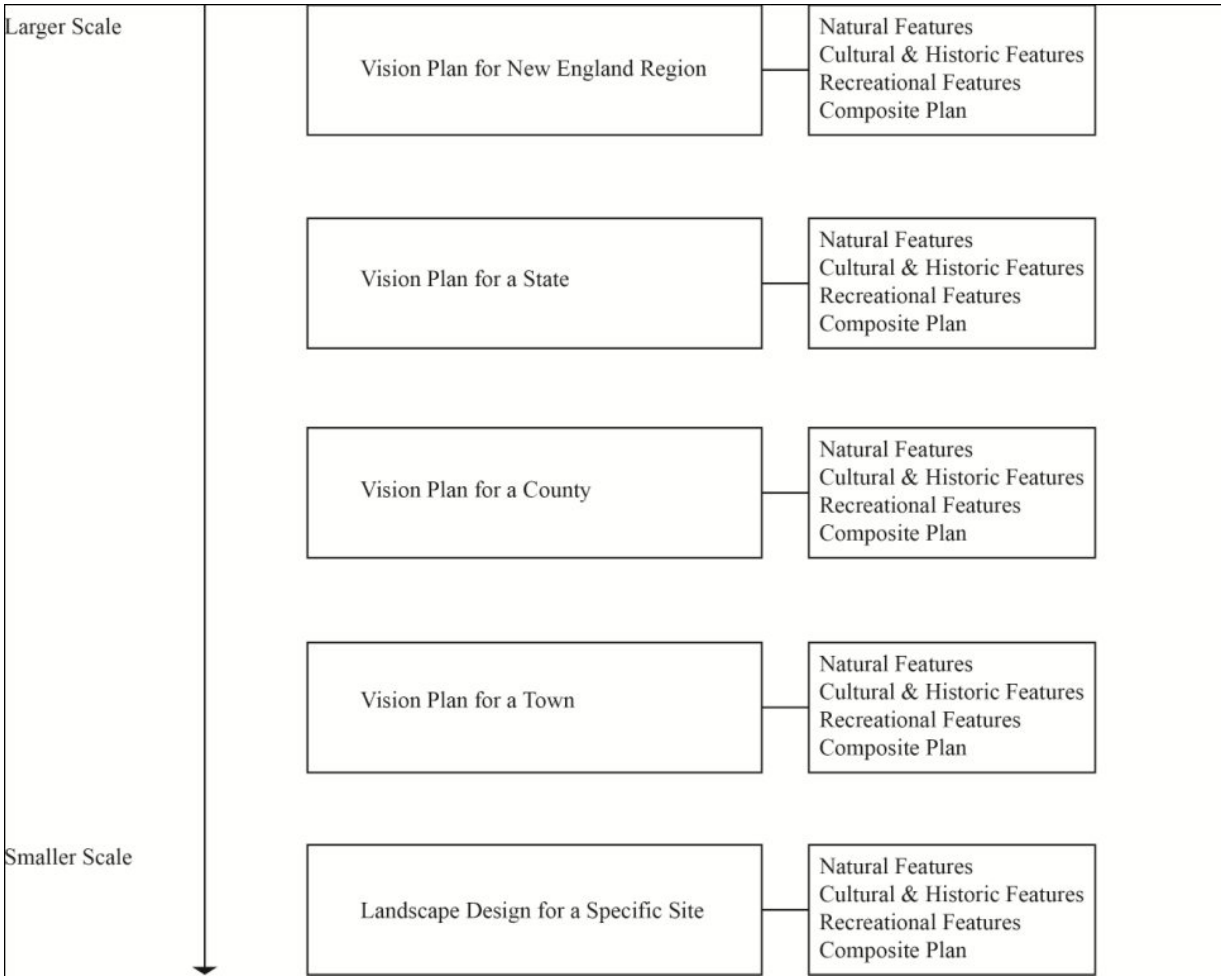
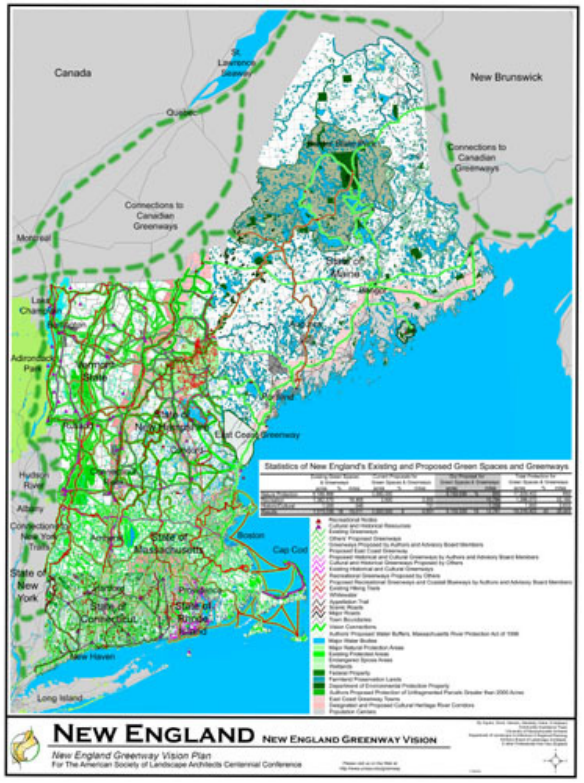


Fig 19. Multi-level and multi-functional thinking in New England Greenway Vision Plan (Image resource: Xiao Zhou).

The following Figure 20 to Figure 24 give a better idea about how those different levels of greenways are proposed in the whole project.



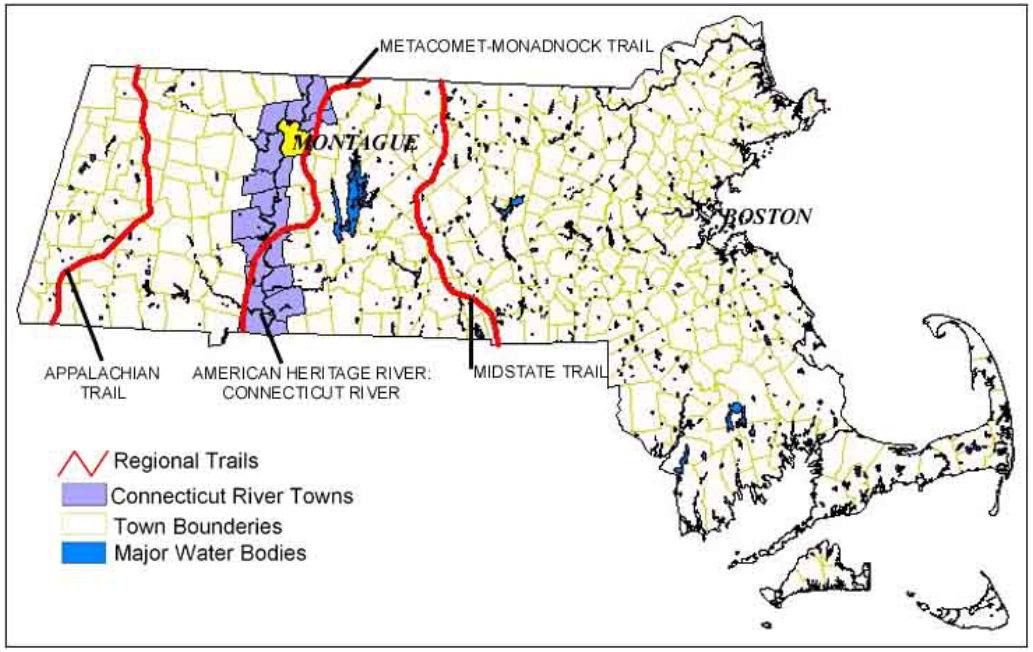


Fig20. The Greenway Vision Plan for New England(Fabos,2004)

Fig21. The Greenway Vision Plan for Massachusetts(Fabos,2004)

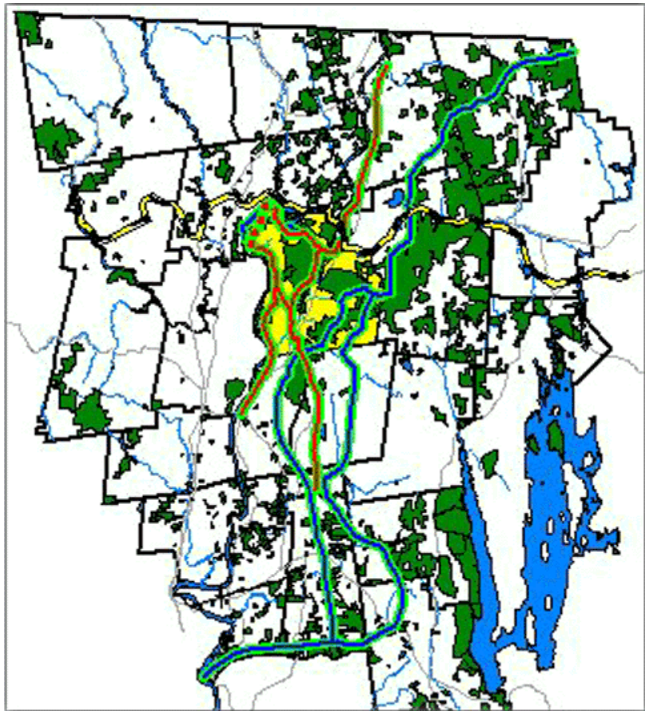


Fig 22. The Greenway Vision Plan for Franklin County, Massachusetts (Fabos,2004)

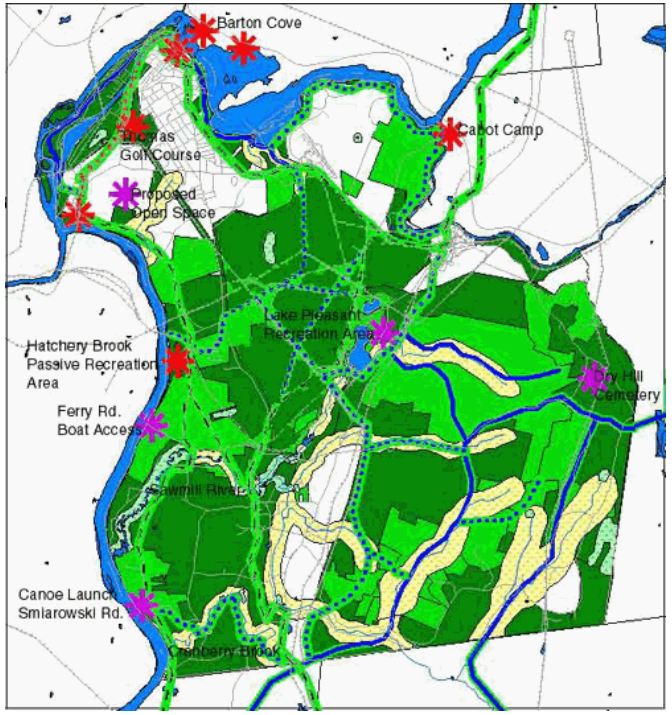


Fig 23. The Greenway Vision Plan for Montage Town, Massachusetts (Fabos,2004)

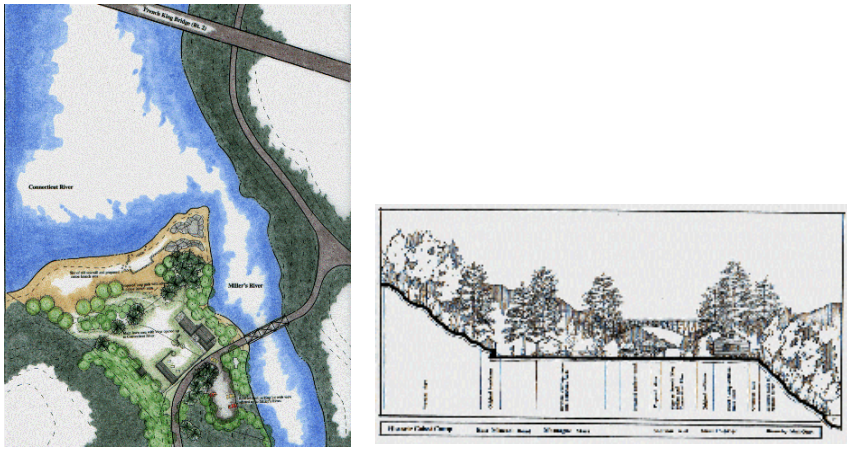


Fig 24. The Site Plan and Section for Cabot Camp,MA (Fabos,2004)

Also worth mentioning is the website (http://www.umass.edu/greenway) the METLAND team created to convey the information freely to the world. All the information of the New England Greenway Vision Plan is categorized in a very clear hierarchy. By checking the website, people can easily understand the whole planning and greenway design process.

3.2. Port Lands Estuary

Location: Toronto's post-industrial Port Lands, Ontario, Canada

Size: 280 acres

Landscape Architect: Micheal Van Valkenburgh Associates (MVVA), Inc. (Leader of a multi-discipline team with architects, planners, hydrologists, and many other experts as well.

Time: Master Plan completed in 2007, implementation unknown.

Client: Waterfront Toronto

The background of this project traced back to 1999 when the 'Waterfront Revitalization Task Force', a task force of the City of Toronto, the Government of Canada and the Province of Ontario was established to study the future of the Toronto waterfront(Wikipedia). In 2005, WATERFRONT Toronto (http://www.waterfrontoronto.ca/) formed a design review panel, the first in Toronto, to help ensure that waterfront revitalization projects set new standards for design excellence (WATERFRONT Toronto). The MVVA design proposal results from the winning solution of an intensive eight-week design competition with an international team of designers, engineers, and ecologists, headed by the landscape architects (American Society of Landscape Architecture, 2008).

The proximity of the geography context to my terminal project and the sustainable design approaches are the major reasons why this project is selected as a precedent. This design proposal received the 2008 ASLA Honor Award for Analysis and Planning. The award

jury complimented on the project: "*Ecological and sustainable strategies drive the program, which is a fresh approach to urban design. The landscape architect has created images that convey a compelling story to convince the public and the authorities to make something happen. Sweeping and powerful*" (ASLA,2008).

Fig 25. Port Lands Estuary. (Image resource: ASLA)

Major world cities such as Toronto are in transition and many are recycling their industrial pasts. The MVVA team proposed a transformation of the Toronto Lower Don Lands from port to sustainable "green" city to unfold on this particular site. The proposal

imagines a new type of territory where city, lake, and river interact in a dynamic and balanced relationship – an urban estuary. The team has reframed the design challenges into 4 major considerations (MVVA Team Design proposal, 2007):

1, Shift pre-established boundaries to open up new possibilities and relationships among city, river, and lake.

2, Relocate the mouth of the Don River to a place "where it wants to be," at the edge of the lake.

3, Integrate and consolidate new and existing neighbourhoods.

4, Employ a science-based approach to use river sediment and ecological principles to give form to the project.

In responding to the challenges, the team proposed the following strategies:

1, Providing restored mouth for Toronto's Don River

2, Recapturing the waterfront in a substantive way

3, Making sustainable neighborhood for the 21st century

4, Inviting diverse lifestyle opportunities

5, Ensuring an active and vibrant public realm

6, Providing high-quality materials in buildings and public spaces

7, Providing a good balance of motorists, cyclists, and pedestrians

The MVVA's concept follows a question asking where the mouth of the Don River wants to be. Instead of creating naturalized banks along the straight course of the existing channel connecting the Don River with the lake, the Port Lands Estuary proposal keeps the Keating Channel as an urban artifact and neighborhood amenity and recreates a new mouth for the river that flows logically from the upstream source, by passing the abrupt right turn created by the channel (ASLA). A large new meandering riverfront park becomes the centerpiece of a new mixed-use neighborhood (Fig 25). "The remaining land would then be populated with mixed uses, including housing, retail uses, employment opportunities, and light industry. The Keating Channel would retain a harder urban edge, while the new "estuary" of the Don River would form a linear park complete with trails, recreational fields, and restored natural areas. The new estuary would also help manage stormwater from the proposed development" (Arvidsom 2008).

The sustainable approaches the team has proposed includes various aspects such as regional ecological restoration; hydrology & flood control; habitat restoration; stormwater management; creating microclimate; recycling and reusing the existing site materials like keeping the Keating Channel and using the massive sediments and woody debris as project materials (Fig 25). Based on an ecological design idea,

the changing of the existing river's edge, removal of huge areas of land, and the creation of a naturalized river's mouth and floodplain will help to create a vibrant neighborhood and complete DNA of a vibrant city: a mix of life-cycle housing, commercial, cultural, and work spaces, public realms, parkland, and access to water (MVVA Team Design Proposal, 2007).

3.3. Buffalo Bayou Promenade

Location: Houston, Texas

Size: 23 acres

Landscape Architect: SWA Group, Houston Texas

Time: Completed in 2006

Client: Buffalo Bayou Partnership; City of Houston; Texas Department of Transportation; Harris County Flood Control District.

Buffalo Bayou Promenade is an important part of the Buffalo Bayou trail system. It extends from the historic Sabine Street bridge, just west of the Central Business District to Bagby Street in the heart of the Arts and Entertainment District. This new 23-acre (93,000 m2) recreation area, complete with 1.4 miles (2.3 km) of hiking and biking trails, was opened in 2006 and was designed by the international

renowned landscape architecture firm, The SWA Group. The master plan converted a trash-soaked eyesore — intimidating to pedestrians and detrimental to flood control efforts — into 3,000 linear feet of urban park that provides a prominent gateway to downtown Houston (ASLA).

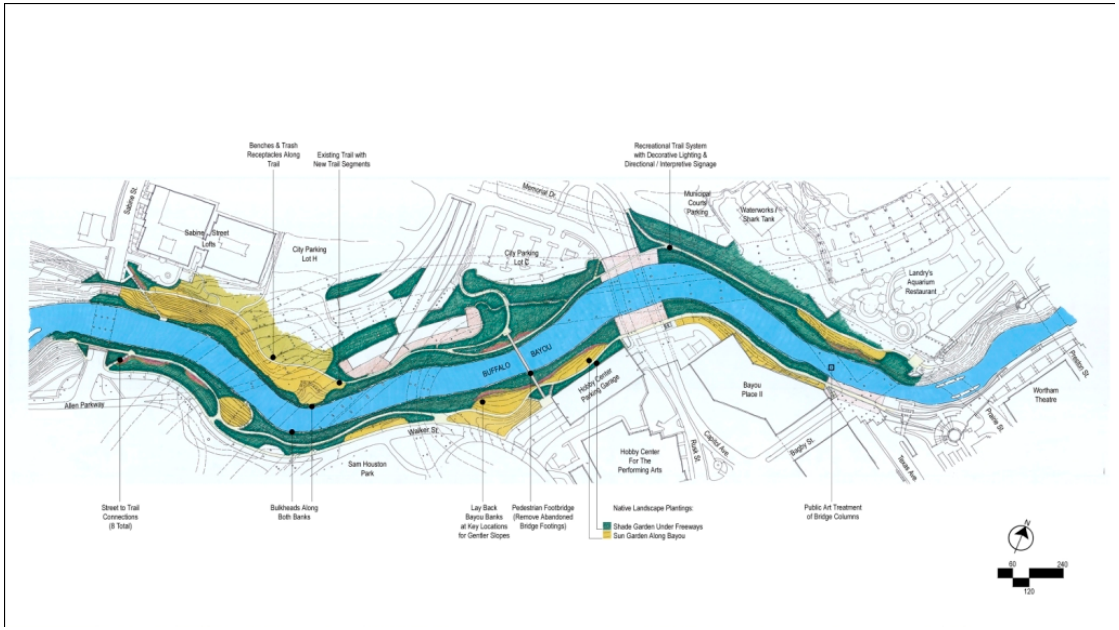


Fig 26. Master Plan of Buffalo Bayou Promenade. (Image resource: http://www.asla.org/2009awards/104.html)

The towering freeway structures that criss-cross the river corridor in the site posed great challenges to the designer. It is the similar situation in this Yantian greenway project. They blocked out sunlight and spilled concentrated sheets of water off their sides during rain storms(ASLA). Extensive re-grading of the site enabled the team to lay back slopes, thereby helping to improve views into the park while also reducing the impact of erosion and improving flood water conveyance. A system of stair and ramp connecting points at each roadway crossing provide safe, convenient and frequent access opportunities. Both functional and artistic lighting are used to enliven the space at night (Landscape Architecture Magazine, 2009). Commissioned artwork, poetic interpretations of canoe frames, frame each park portal providing visitors a symbolic link between the city's arts district and its historic channel (ASLA). Instead of walls, a system of gabions – wire baskets filled with stone – was used along the edge of the bayou. They act as an environmentally friendly edge, they are permeable and they create spaces for plants and benthic bugs which are important part of the food chain (Landscape Architecture Magazine, 2009).

Fig 27. Inovative lighting, accessible friendly bikeway and steps, ecologically use of gabion as reparian. (Image resource: http://www.asla.org/2009awards/104.html)

The 2009 ASLA Professional Award Juries commented "This project sends a great message on scale, proportion, materials, and perseverance." Similar opportunities are found in my terminal project. Many innovative and sustainable approaches could be attached to this proposal by studying this masterpiece of sustainable urban design.

The three case studies convey some important greenway planning and design ideas that can be adapted in the Yantian greenway project. The New England Greenway Vision Plan describes the concept of multi-level and multi-functional thinking through out the planning process; the Port Lands Estuary project incoporates sustainable urban development approaches in varies aspects; the Buffalo Bayou Promenade successfully remediates and resue the wasteland. Those methods are of extreme importance to the Yantian urban greenway project.

CHAPTER 4 - Project Background

This chapter will first introduce the overall Pearl River Delta (PRD) Greenway System and the relationship between PRD Greenway, Shenzhen Greenway and Yantian Greenway. Then the chapter will describe the background of the Yantian district including the context and geographic character, natural character, history and existing condition of the Yantian greenway and its potentials.

4.1. Introduction to the PRD Greenway System

The Yantian district is located in Shenzhen city, Shenzhen city is a part of Pearl River Delta which is in Guangdong Province of China. (Fig 28).

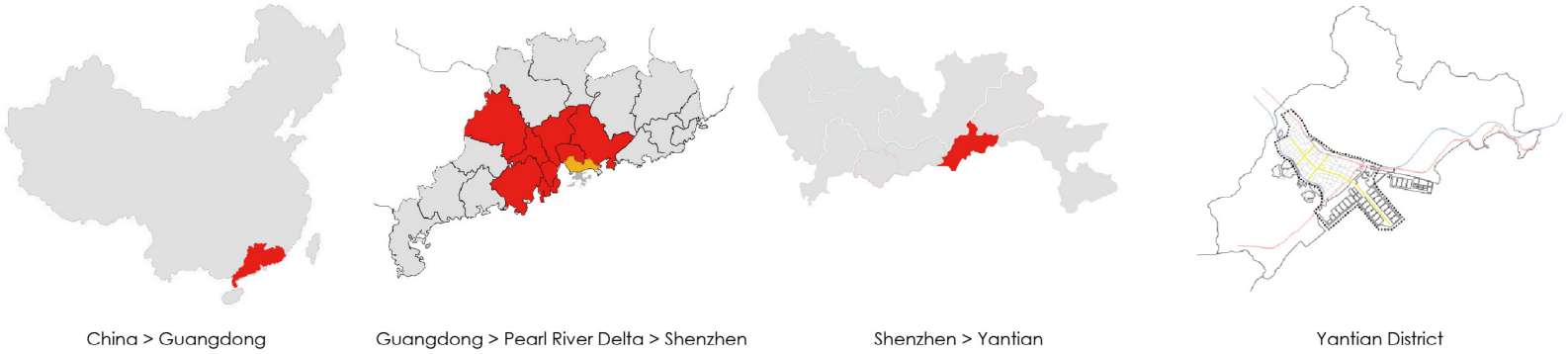


Fig 28. Location of Yantian District and its relationship to Shenzhen, Pearl River Delta and China.(Image resource: Xiao Zhou)

4.1.1. Introduction of Pearl River Delta (PRD) Regional Greenway

China has rich experience in greenway planning ever since ancient times (Yu, 2004). The traditional Chinese planning and design philosophy advocates the harmony of human beings and nature and has inspired the planning of Pearl River Delta Regional Greenway, a new project that has been initiated in Guangdong Province. The Pearl River Delta Regional Greenway plans to reinterpret the original greenways in China. With mountains, forestry, rivers and oceans as the elements, a planning framework of the Pearl River Delta Regional Greenway is created to connect the important biodiversity and green spaces in the region. Therefore, a multi-level, multi-functional and comprehensive Pearl River Delta Greenway Network will be built (He, 2010).

The PRD Greenway system was initiated in 2010, and will be fully built at the year 2012 (Already fully connected in Jan, 2011). According to functions, the PRD Greenway is categorized into three kinds (Guidelines for Planning and Design of Regional Greenways in Pearl River Delta, 2010):

1. Ecological Greenway. This kind of greenway will be built along the streams, river, waterfront and ridgeline. This greenway offers protection to the ecology and biodiversity as well as education and hiking experience at the PRD area. The proposed width is not less than 200m.
2. Suburban Greenway. This greenway will be built as boardwalk, hiking trial and pedestrian along the suburban open space, water edge and open field to connect people to the natural area. The proposed width is not less than 100m.
3. Urban Greenway. This greenway is in the built area. Based on the existing public park, scenic area and road, this greenway provides people a place to walk and jog. The proposed width is not less than 20m.

Type	Length(km)
Ecological Greenway	348
Suburban Greenway	884
Urban Greenway	458
Total	1690

Fig 29. The summary of the length of different functions indicates the ecological greenway is the shortest. (Resource: Guidelines for Planning and Design of Regional Greenways in Pearl River Delta, 2010)

According to level, the PRD Greenway system may also be categorized into 3 kinds: Regional level; City level; Community level. The regional level is about 1690km long and the length of city and community level greenway varies.

In addition, the whole PRD Greenway system includes 6 major routes, 4 connection routes and 22 secondary routes. 18 of those routes go through urban built areas. 4410 km^2 buffer is proposed. About 25.65 million people will be served.

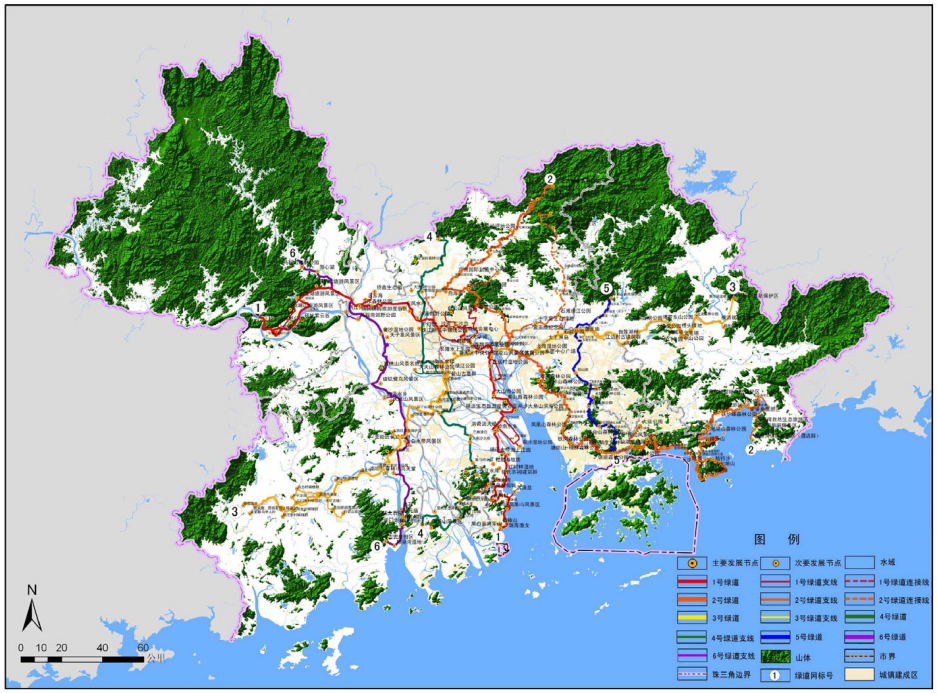


Fig 30. The Master Plan of PRD Regional Greenway.(Image resource: http://www.gd.gov.cn/tzgd/tzgdzt/ldw/)

4.1.2. Introduction to the Shenzhen Greenway

Shenzhen Greenway is an important part of the PRD Greenway system which includes the No. 2 and No. 5 major routes of PRD Regional Greenway that are about 300km in length. The proposed urban level greenway in Shenzhen is about 500km and the community level greenway is about 1200km. The whole project is planned to be completed in 2015.

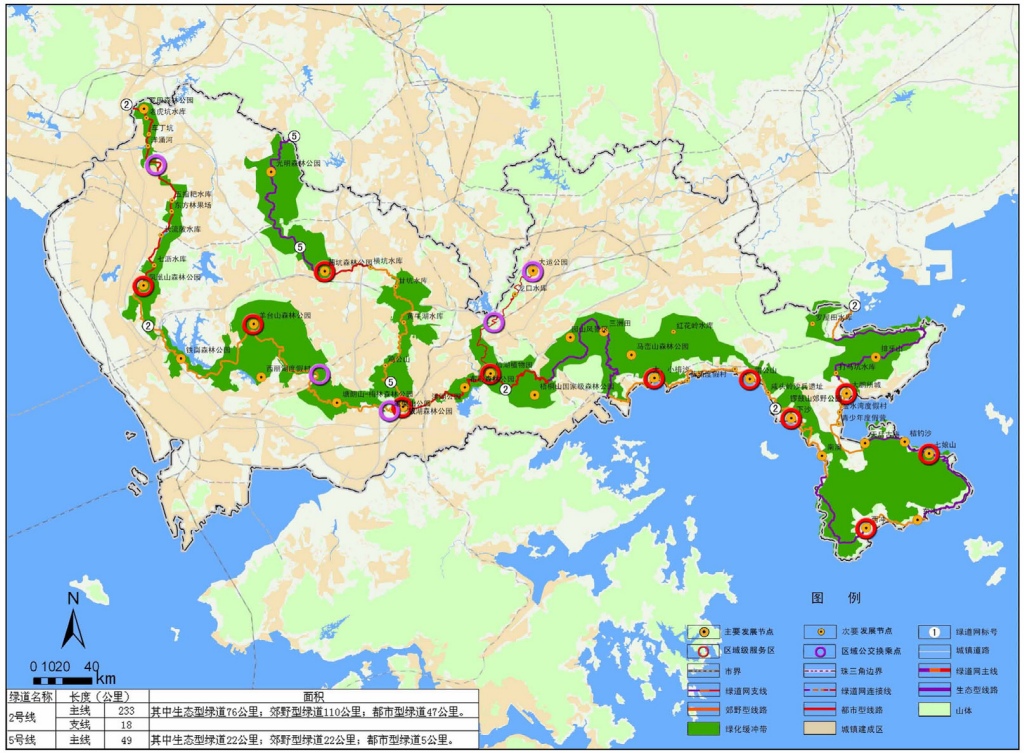


Fig 31. The Master Plan of Shenzhen Regional Greenway.(Image resource: http://www.gd.gov.cn/tzgd/tzgdzt/ldw/)

4.1.3. Introduction to the Yantian Greenway

Yantian Greenway is a sub-division of the Shenzhen Greenway which is proposed to be about 60 km long with about 19.5km regional greenway and some other urban and community greenway. This project will redesign the Yantian Greenway as an ecological model for future development.

Fig 32. The Map of Yantian Regional Greenway(shown in red line). Green dots stands for major attractions.(Image resource: BLY Design Institute)

Name/Type	Regional	Urban	Community	Total
PRD Regional Greenway	1690			
Shenzhen Greenway	300	500	1200	2000
Yantian Greenway	19.5	40.5		60

Fig 33. Summary of the three level greenways (unit:km)

4.2. Context and Geographic Character of Yantian District in Shenzhen.

4.2.1. Location

Yantian district is located in the south of the Pearl River Delta (PRD). The PRD is the low-lying area surrounding the Pearl River estuary where the Pearl River flows into the South China Sea. The PRD is one of the most densely urbanized regions in the world, and one of the main hubs of China's economic growth.

Fig 34. Yantian District and Pearl River Delta.(Image resource: Google Map)

Yantian District is one of the seven districts of the Shenzhen City in Guangdong Province of China. It is adjacent to Shenzhen River in the south, and is surrounded by Luohu and Longgang districts in Shenzhen. Until March 1998, Yantian was part of Luohu District. The size of Yantian district is about 72.63 km². It contains 4 sub-districts: Meisha (梅沙); Yantian (盐田); Shatoujiao (沙头角); Haishan (海山)

Located on Mirs Bay, Yantian is the place of some of Shenzhen's best-known tourist beaches, Dameisha and Xiaomeisha. Also located here is Yantian Port which is one of the largest container shipping ports of the world. The Yantian greenway is part of the Shenzhen greenway system. It has the typical geographical context of Shenzhen with mountains, coastal line and densely populated urban area.

Fig 35. The map of important places in Yantian district. (Image resource: Xiao Zhou)

4.2.2. History

The name Yantian, literarily “Salt Pan”, comes from the Yantian village with plenty of salt pans. The earliest record of the village is around 1800 AD in Qing dynasty. The district was officially set up in 1998. Now, the Yantian district has been developed to a famous harbor and tourism area which people call it “the golden coast”.

Fig 36. Salt Pan (Image resource: http://www.glulu.com/messages.asp?articleid=792&dalei=112)

4.2.3. Topography

The topography of Yantian district mainly consists of coastal lowlands and mountains that are typical of Shenzhen City. The district faces Dapeng harbor which connects to the South China Sea. The topography of the area has great merit in providing amenities for recreational development, both on mountains that provide nice views over the urban area to the port and harbor, and along the waterfront.

Fig 37. Topography of Yantian. (Image resource: Google Map)

4.2.4. Hydrology

The most important water body that go through Yantian district is the Yantian river. It connects the Dapeng harbor (Mirs Bay) with the urban area and Henggang village to the north of Yantian district.(Fig 38) Most of the stormwater and sewage go to this river and finally to the Mirs Bay.

4.2.5. Green space

Yantian district is surrounded by two major forest parks – Maluanshan forestry park and Wutongshan forestry park, the urban area cuts and breaks the connection of the two parks. In addition, there's no efficient green connection between the two parks (Fig 38) which

actually should play an important role in the regional green space network. The lost of this connection fragments the general green space network reduces the connectivity level of the overall green network. A finer scale analysis could be found later at chapter 4.3.

4.2.6. Land Use

The dominant land uses in the selected area are residential and storage use. The administrative land (land for government use) also occupies considerable amount of overall lands since Yantian is an important port in China. Commercial areas are scattered in the residential area and partially gathered along the central road. The rate of public green area is very low and not in a system. Generally speaking, the whole area is like an impervious knife that cuts through the two forestry parks. (Fig 38 & Fig 43)

4.2.7. Transportation

The focus area in Yantian district is surrounded and defined by a series of major railways and highway. Those railways and highways act as a strong edge of the focus area. They are also a harsh end of the forest parks (Fig 38) and they are supposed to have caused problems in many ecological aspects such as barrier for wildlife crossing, block for the healthy connected water system, unpleasant visual elements among others.

Fig 38. Some important analysis.(Image resource: Xiao Zhou)

4.2.8. Government and Stakeholder

The PRD Greenway System is implemented through a special top-down strategy. The PRD Regional Greenway is managed by Department of Housing and Construction of Guangdong Province. The Shenzhen Greenway is managed by a team named "Shenzhen Greenway Planning and Construction Management Team". The leaders of the team are the mayor and vice mayors. The team member includes many influential governmental departments like the land use commission, transportation commission and city management department. The Yantian Greenway is also supervised by this team.

The special top-down approach to planning creates both advantages and disadvantages. Large-scale projects are often planned and established in a short time. Although there is little concern about funding and labor, the analysis is usually not comprehensive enough because of demanding deadlines. In this project, the PRD regional greenway which is about 1,690 kilometers long, has been ordered to be completed in 3 years from 2010 to 2012. In addition, as urbanization in China is growing rapidly, greenways are built with the emphasis on recreational use and economic purpose rather than habitat protection and ecological security concerns (Sources from official website, People's Government of Guangdong Province).

The other challenges created by this special management strategy include: Lack of public involvement caused incomplete analysis that results in poor planning decisions. Short term study period brought misunderstanding of ecological function. Strong government control reduces public involvement during planning design process. Demanding deadline brought about poor construction quality.

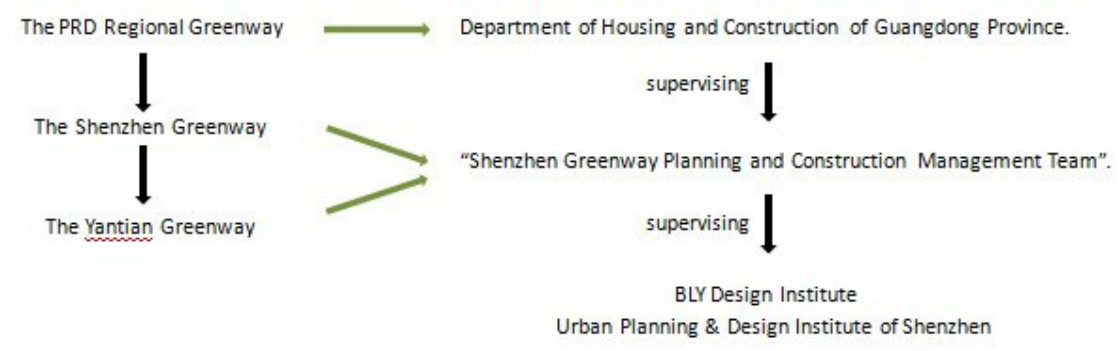


Fig 39. PRD Greenway System management system.(Image resource: Xiao Zhou)

4.3. Context of Focus Area in Yantian District.

4.3.1. General Information

Besides the Yantian river, there exists some smaller visible streams that are fragmented and channelized. Except drainage, those streams almost lost other functions and are not appealing to people. However, those water bodies have a potential to be connected as a larger water system. (Fig 40) The official urban grid proposal follows a rigid checker-board pattern, but the existing condition is much more complex. Current paths and roads go through informal urban villages and temporary storage buildings. Part of the main road follows an urban stream with a meandering, poorly-organized pattern. (Fig 40) There are three major green patches in this area, but they are separated by paths, drives and urban villages. They have a great potential to be linked as a necklace that connect the adjacent national forest parks. (Fig 40)

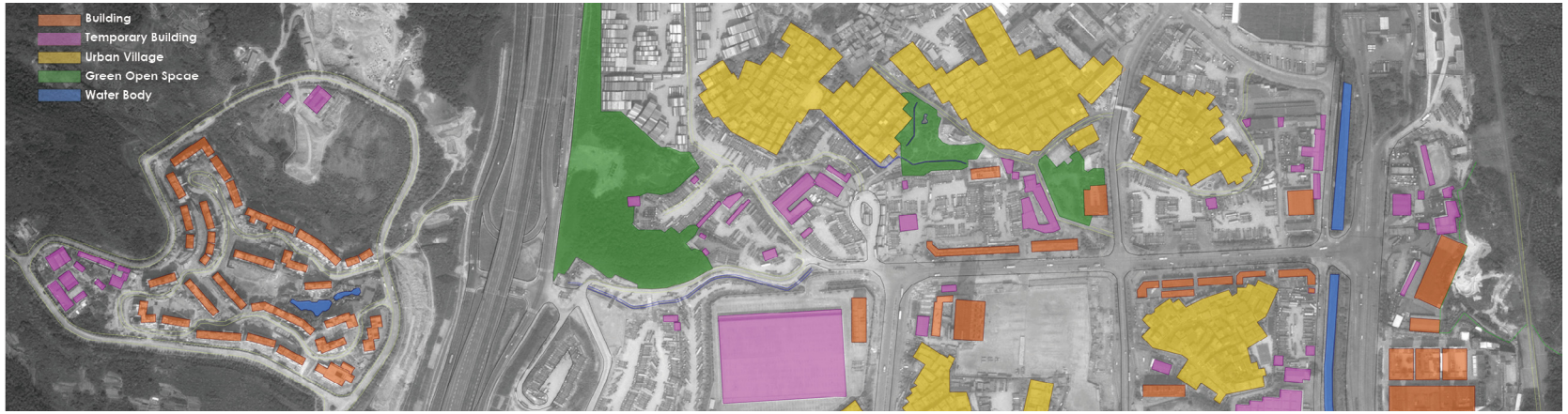


Fig 40. The analysis map of existing condition, yellow is urban village, purple is temporary storage building, red is existing building, green is existing green open space, blue is visible water body. (Image created by Xiao Zhou)

4.3.2. Urban Village

Urban villages occupy a large part of the focus area. It is a unique phenomenon that forms a common part of China's urbanization efforts. They are commonly inhabited by the poor and transient, most of them are heavily populated, overdeveloped, and lack infrastructure. Some villages' building density is greater than 70%. They are composed of overcrowded multi-story, poorly-constructed buildings ranging from three to five (or more) floors, and narrow alleys, which are difficult for vehicles to pass through. This project will partially address this issue since it's a very complex issue that cannot be resolved by adding a greenway. (Fig 41)

Fig 41. Urban village, Temporary storage building and container in Shenzhen. (Image resource: Google Image)

4.3.3. Container and Temporary Storage Building

As one of the most important port in China, Yantian district has a considerable amount of land for storage use to keep the large and small containers. Also some temporary buildings are developed to preserve specific goods. Those senses form a unique sense for the district. (Fig 41)

4.3.4. Existing Photos

The following photos show the existing challenges in the focus area of Yantian district.

Fig 42. Existing photos of the focus area(Images resource: Xiao Zhou).

CHAPTER 5 – Yantian Urban Greenway Design Proposal

5.1. Major challenges and Opportunities in the Selected Urban Area:

Major challenges in the selected urban area:

1) Lack of green space in urban area which links the two forestry parks and make a healthy greenway network.
2) Water pollution in and around Yantian River which occupies a considerable part of the proposed urban greenway.
3) Singular land use which is not a sustainable urban development approach.
4) Loss of Cultural identity which is of crucial cultural importance for a multi-functional greenway.
5) Lack of recreational open space which plays a significant part of healthy urban life.
6) Misunderstanding of ecological approaches in planning and design.

5.2. Strategies

Proposing a new urban greenway which offers the following functions:

1) Green space that connects to the forestry parks.
2) Stormwater management and plants for phyto-remediation, flood reduction, and water quality improvement.
3) Some mixed land use with consideration about sustainability.
4) Provide a new identity to the area.
5) More public open space with multi-functions
6) Environmental and ecological education

5.3. Suggested Land Use Plan

In the official land use proposal, there is about 10% green open space of the overall land and it mainly proposed singular land use. Based on this plan, I suggested transferring a few facility, tax-free and tourism land into green open space to create an ecologically friendly green network. As a result, the percentage of green open space has been raised to around 20%. In addition, some mixed-use residential lands are suggested based on the singular residential land (Fig 43).

Land Use in Yantian District	Percentage (Before Greenway)	Percentage (After Greenway)
Industrial	8%	8%
Commercial	5%	5%
Residential	20%	20%
Green Open Space	10%	20%
Storage	17%	17%
Tax-free	8%	5%
Tourism	7%	2%
Facility	5%	3%
Administrative	15%	15%
Education	5%	5%

Fig 43. The official land use proposal and suggested land use proposal.(Image created by Xiao Zhou)

5.4. Conceptual Plan for the Selected Urban Area

5.4.1. Master Plan

Based on the analysis of Yantian district, a conceptual plan is proposed to create a multi-functional urban greenway. In this conceptual plan, many new green open spaces and trees are added to make green connections through the focused urban area and along the Yantian river. The design detail could be found in Figure 44 & 45.

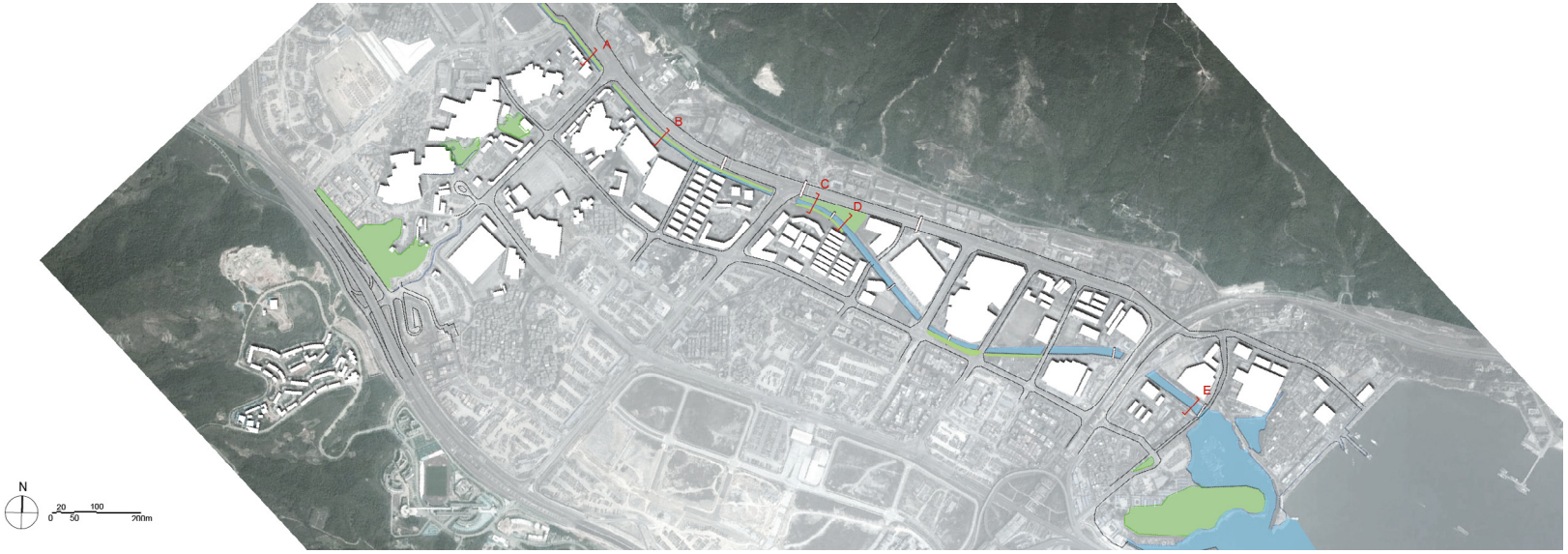


Fig 44. Existing condition of selected urban area in Yantian district. White color shows existing building outlines, green color shows existing green open space and blue color shows existing water body. (Image created by Xiao Zhou)

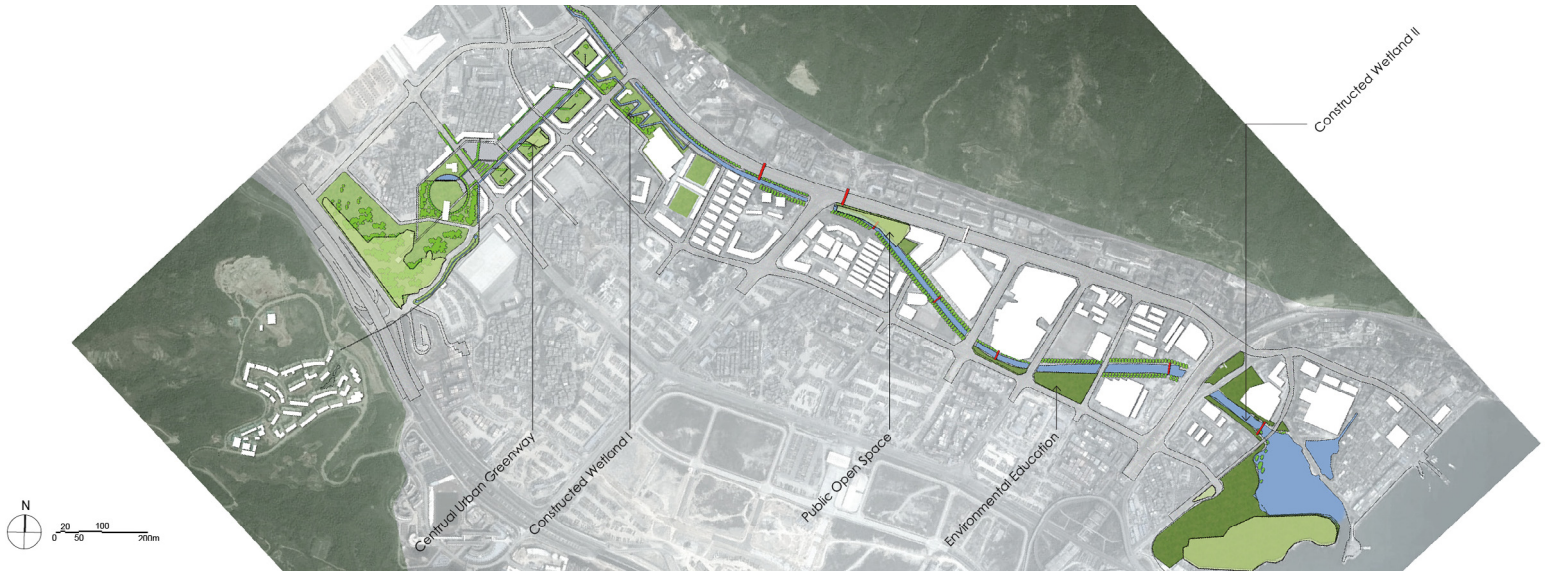


Fig 45. Conceptual plan for selected urban area in Yantian district. The dark green shows proposed green open space based on the study of existing green open space (shown in light green). There are several major functions of those different green spaces including: a central urban greenway (which will be designed in detail in the following proposal), two constructed wetlands a public open space and a green space for environmental education (Image created by Xiao Zhou).

5.4.2. Sections

In order to conduct a more scientific design for the selected urban area, several existing condition sections have been studied and new approaches have been proposed based on the study.

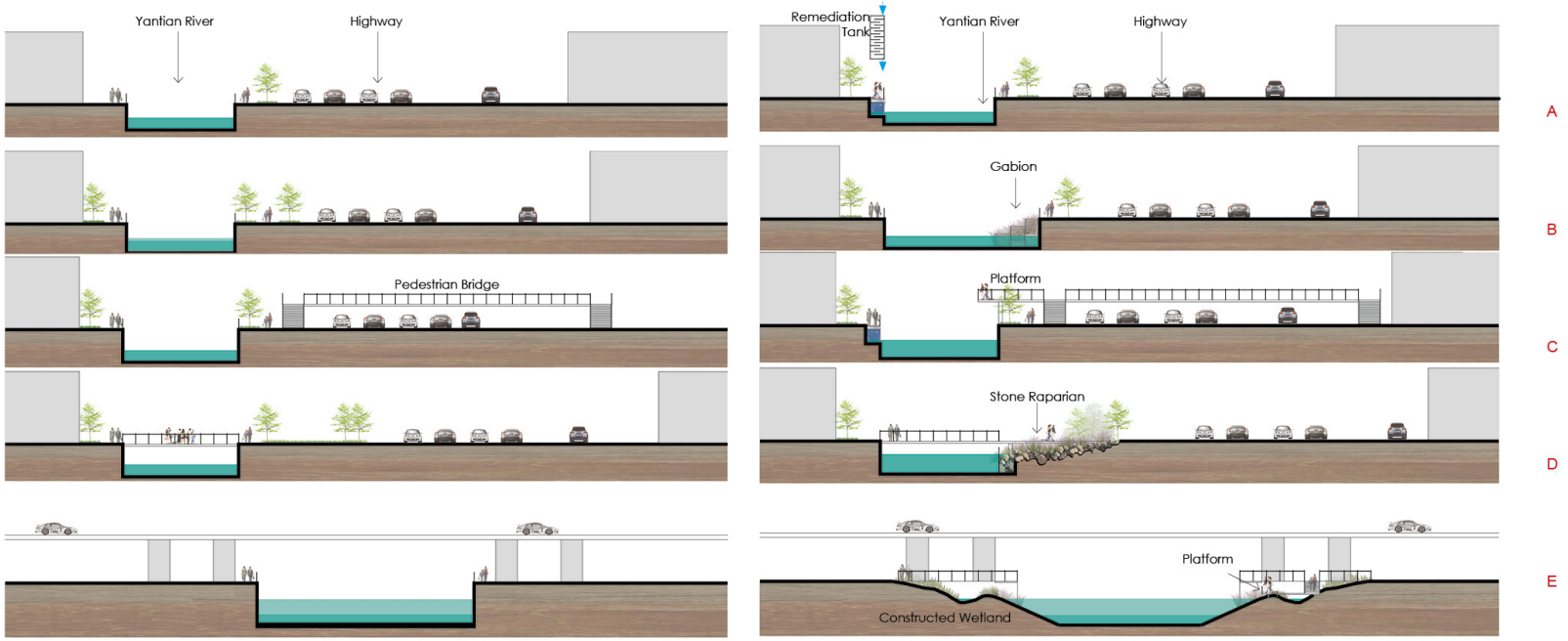


Fig 46. Existing condition section & proposed sections.

Section A: Phyto-remediation tank is added to one side of the river to purify the polluted water as well as provide remediation education opportunity.

Section B: One side of the river has been transferred into a gabion riparian, the gabion provide space for plants and benthic to live and clean the water through ecological function.

Section C: An observation platform is added to the pedestrian bridge for people to watch the remediation process in the other side of the river to enjoy and sense and learn about the remediation process.

Section D: The canalized riparian edge has been changed into a stone riparian edge to make it accessible as well as provide water purification function.

Section E: The canalized river and not pedestrian friendly space under the express way have been refined as a constructed wetland with platform, steps and paths that provide accessibility and remediation function as well as environmental education opportunity.

5.5. Schematic Plan for Focus Area

5.5.1. Design Concept

The design concept for the focus area is to propose a multi-functional urban greenway (Fig 47) that integrates public open space, commercial area, stormwater management system, community space as well as environmental education(Focus area existing analysis can be found at Figure 40).

Fig 47. Design concept.

5.5.2. Schematic Plan

As shown in the schematic plan, a new multi-functional urban greenway has been proposed in the focus area with a green connection between the two forest parks (Fig 48). This plan combines an urban forest, a public open space, a commercial avenue, a constructed wetland and a mixed-use residential area together to form a sustainable urban life (Fig 51). The non-vehicle path system includes a major path system and a secondary pathway (Fig 50) which is pedestrian friendly. Based on analysis of existing visible water body of the site, a connected urban stream is proposed to bring vitality to the urban area and deal with stormwater in a more ecological way (Fig 49). The stormwater will be purified and partially evaporated into atmosphere through rain gardens, green roof and pond. The extra water will be drained into the visible urban stream and finally to Yantian river.

Fig 48. Master Plan

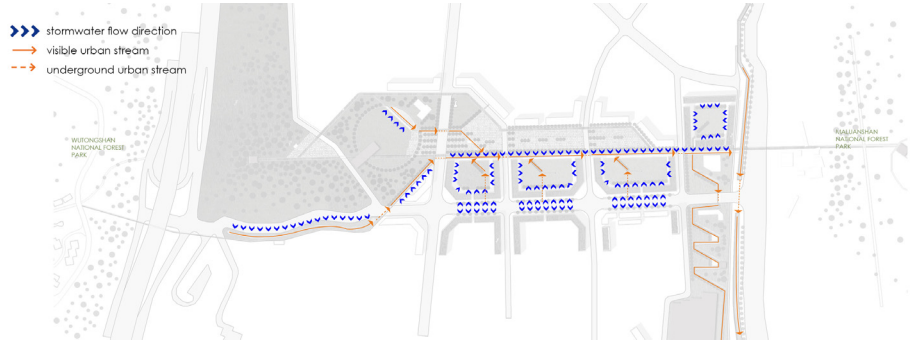


Fig 49. Stormwater movement.

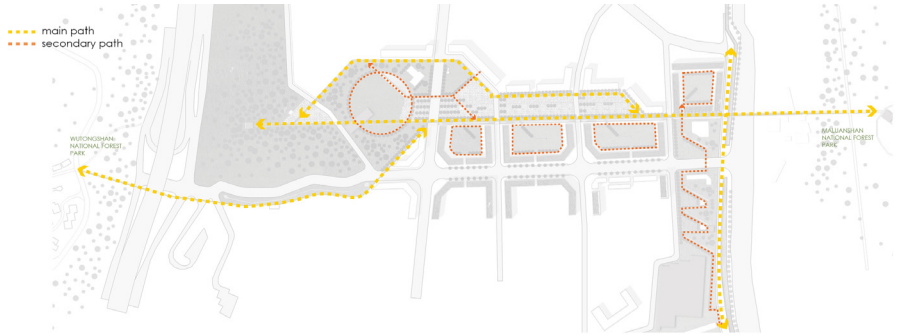


Fig 50. Pathway system

Fig 51. Functional zone

5.5.3. Sections

Three sections are created to conduct an in depth design of the focus area in a vertical perspective.

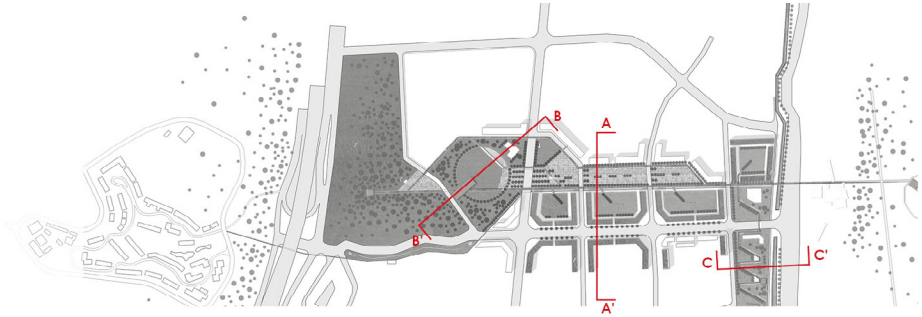


Fig 52. The location of three sections.

Section A: This section shows the relationship between commercial area (left), community space (middle) and the green street (right) with rain garden. The buildings that shape the edge of the space are mixed-use buildings, the first floor is commercial use, other floors are residential use. Sustainable pavements are also considered, includes permeable paving, boardwalk made by recycled wood. In addition, some solar lights are proposed to use sustainable energy. The section below shows the stormwater treatment system. The stormwater will first be captured by green roofs and rain gardens, as mentioned above, the water will be partially evaporated into air and purified by the plants on the roof and in the garden. The extra water will be drained into the pond in community space and then to the central urban stream. After a series of treatment, it will finally be drained into Yantian River.

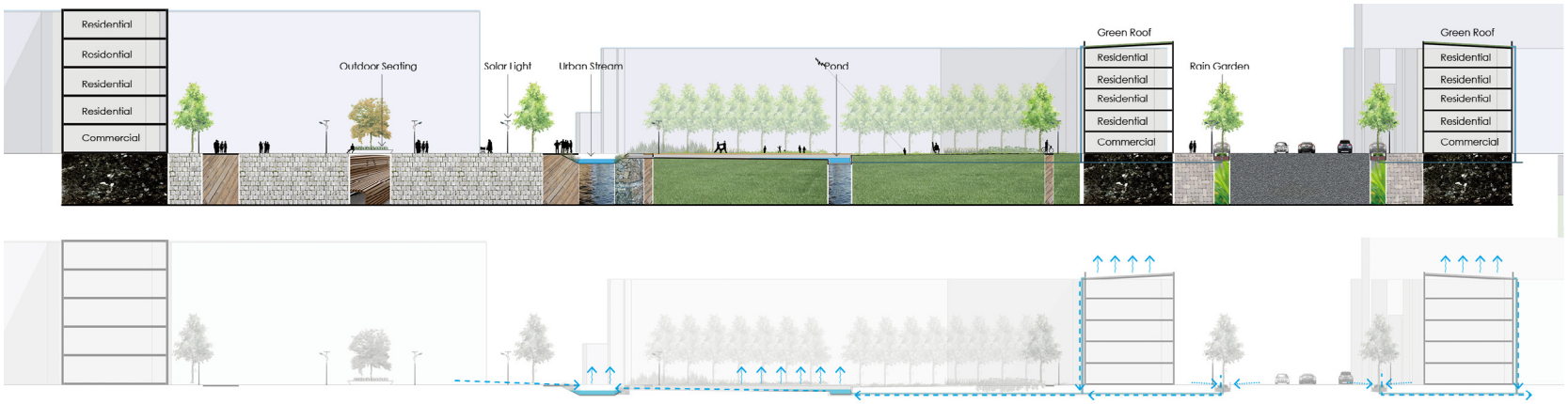


Fig 53. Section A

Section B: This is a section cut through the public green open space zone. It shows the spatial organization method of this zone. The building in the left is an art gallery replacing the nearby urban village. The structure on the right is a stage and workshop replacing a big temporary storage building. The shallow pond next to the green open space is a place for people to get close and play with water as well as a place to collect stormwater from the open space.

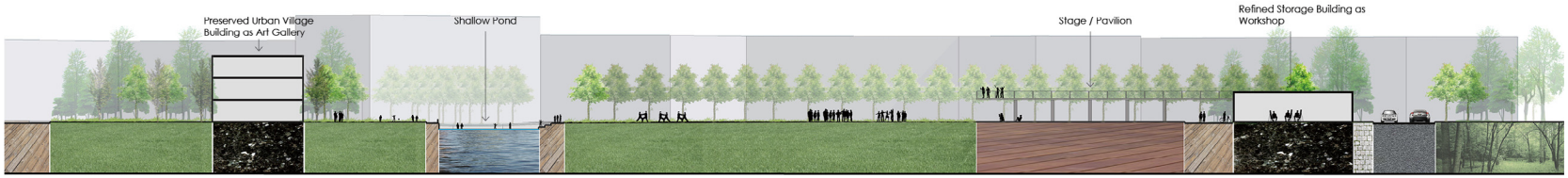


Fig 54. Section B.

Section C & C': This is a section cut through the constructed wetland to show the relationship of different elements of it. Board walk, platform and an observation room transferred from a storage building are proposed above the wetland to connect people to this urban green infrastructure. The following section C' gives a better view about how the constructed wetland functioning as a purification system. The water from Yantian river is pumped into a cascading system with different elevation and plants to remediate the polluted water.

Fig 55. Section C.

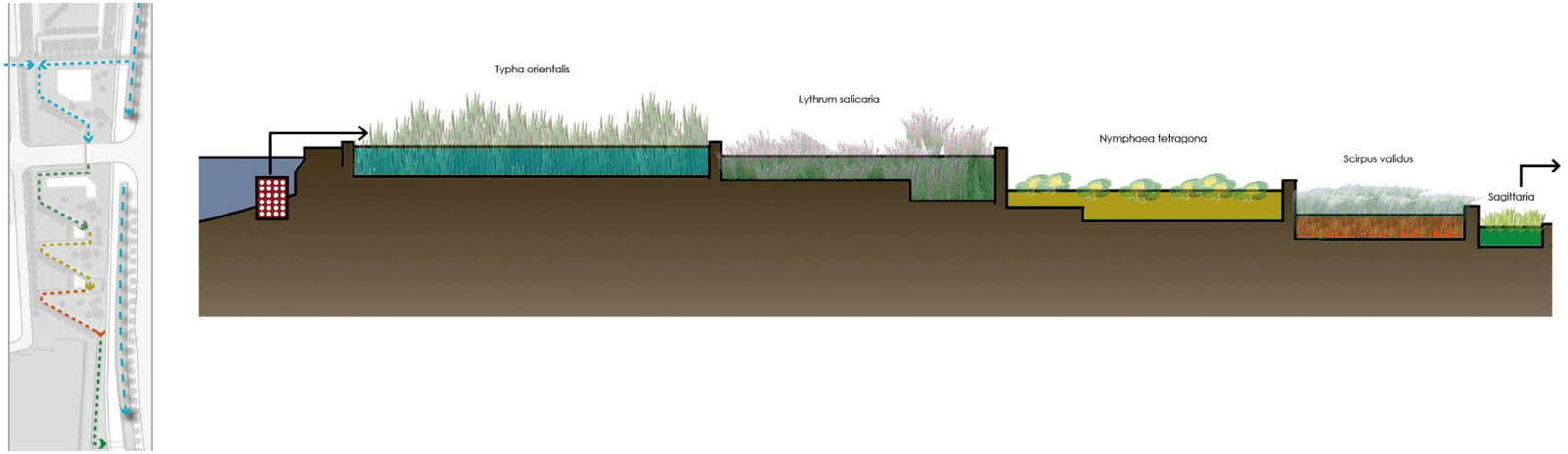


Fig 56. Section C'.

5.5.4. Bird's Eye View

Fig 57. Top left: Constructed wetland; Top right: commercial Street; Down left: Public Green Open Space; Down right: Community Green Space.

5.7. Urban Village Improvement

The urban villages are unique elements in this urban area. In order to deal with its extremely high density, humid and dark environment, this project proposes two scenarios: First is to reconstruct the whole urban village site into a new residential area with high raise buildings. Second is to get rid of some buildings to reduce the density from 70% to about 30%. Both strategies create more public open spaces that connect to and serve the adjacent urban greenway.

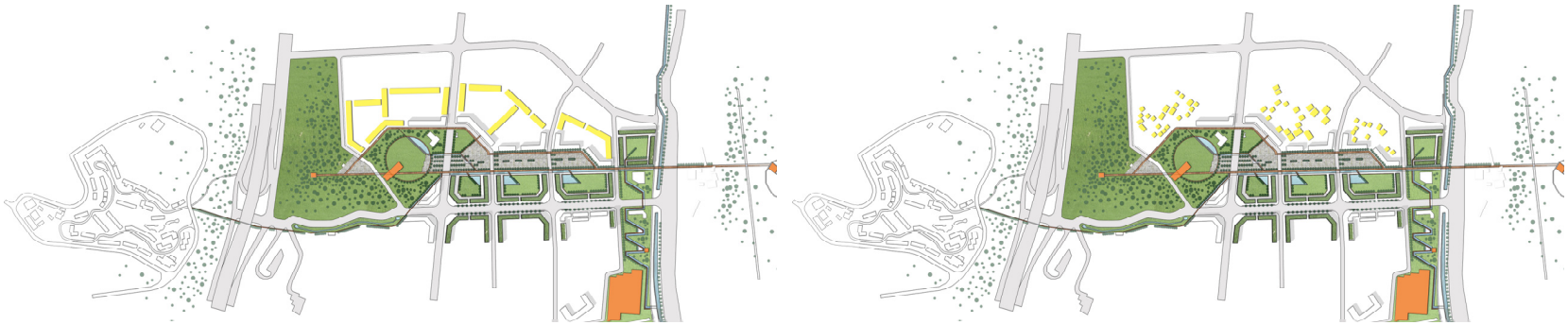


Fig 58. Scenario 1: Reconstructed residential area; scenario 2: Reduce urban village density.(Resource: Xiao Zhou)

5.8. Sustainable Approaches

As a multi-functional urban greenway, sustainable thinking plays an important role in the overall design process. The sustainable approaches could be categorized into the following aspects:

1, Ecological aspect: A complex stormwater treatment system is proposed to deal with the stormwater in an ecologically friendly way (see section A). The constructed wetland provides water detoxification and purification functions as well as habitat for animals. An urban forest is proposed and a large amount of trees are planted, this helps to reduce the urban heat island and provide fresh air and comfortable micro-climate for people. Pervious pavement is used widely; solar light is introduced to the site as a sustainable approach. Most importantly, the urban greenway connects the adjacent two national forest parks and serves as an offensive strategy to reduce the green space fragmentation.

2, Cultural aspect: As a new urban area grown from a small village, this district has almost completely lost its identity. The dominant scene is storage building, urban village and containers. This project reused and transferred some of the urban village and containers into stage, platform and observation room to introduce new function to those structures at the same time keep its appearance in order to find a new identity for them. The existing urban streams are reconnected as a large central urban stream system to reflect the district's geographic context.

3, Economic aspect: The reuse and recycle of existing structures and materials reduce the cost on construction and labor. The mixed-use residential land is also an economically smart approach in sustainable urban development. The overall healthy and sustainable urban environment will generate a better living condition and ultimately reduce the cost on public health.

CONCLUSION

The challenges involved in this project are complex and interwoven which is typical in urban development nowadays: fragmented green spaces; channelized rivers; polluted urban streams and chaotic building arrangements. In order to deal with these challenges, a multi-functional as well as multi-level design idea is essential to the whole process. Greenway's fundamental characteristics make it an appropriate approach in such project. Because of its recent and continued rapid urbanization, China has a challenge to make its new urban areas more sustainable – and it has the important opportunity to demonstrate to other rapidly-growing cites and countries of the world how to live a sustainable urban future.

The research on greenway provides a basis to understand the history, definition, planning process and its relation with sustainable urban design. The design idea is inspired by this research and three precedence studies. Urban greenway design is closely tied to an essence of greenway – sustainability. Guided by this concept, many sustainable approaches are discussed in this project. They include: water remediation; mixed-use building; existing material reuse; stormwater management and public involvement.

In addition, land is extremely valuable in such a densely populated area. Under this circumstance, the compatibility of urban greenway makes it possible to attach multiple functions within a limited amount of land. The open spaces, pedestrian friendly pathway system, the urban stream and a large amount of plants in the proposed urban greenway reshape and revitalize the urban environment. Nature is brought back into the existing urbanized area and will modify the area's microclimate. The urban greenway will promote outdoor

activities and environmental education, these could improve the public health and attitude toward nature in the long run and finally achieve a sustainable urban area.

In conclusion, this project is designed as a model for future greenway development. The PRD Greenway System is an excellent and invaluable opportunity to apply a multi-functional and multi-level sustainable approach to Guangdong province. As the knowledge of greenway planning is not static, the development of PRD Greenway System is also a great chance for China to explore a suitable greenway planning and design strategy for its future development in other regions and cities. This project tried to explore the direction of future greenway development in China and hope to guide it to a more sustainable future.

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